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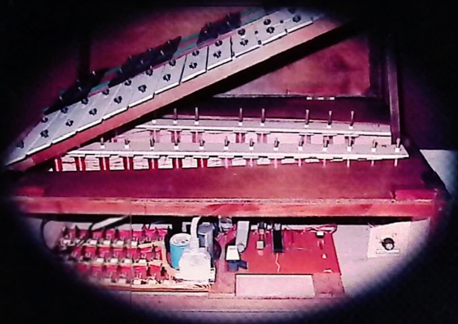
EVERYTHING FOR ELECTRONICS!

September 2001
Vol. 22 No.9



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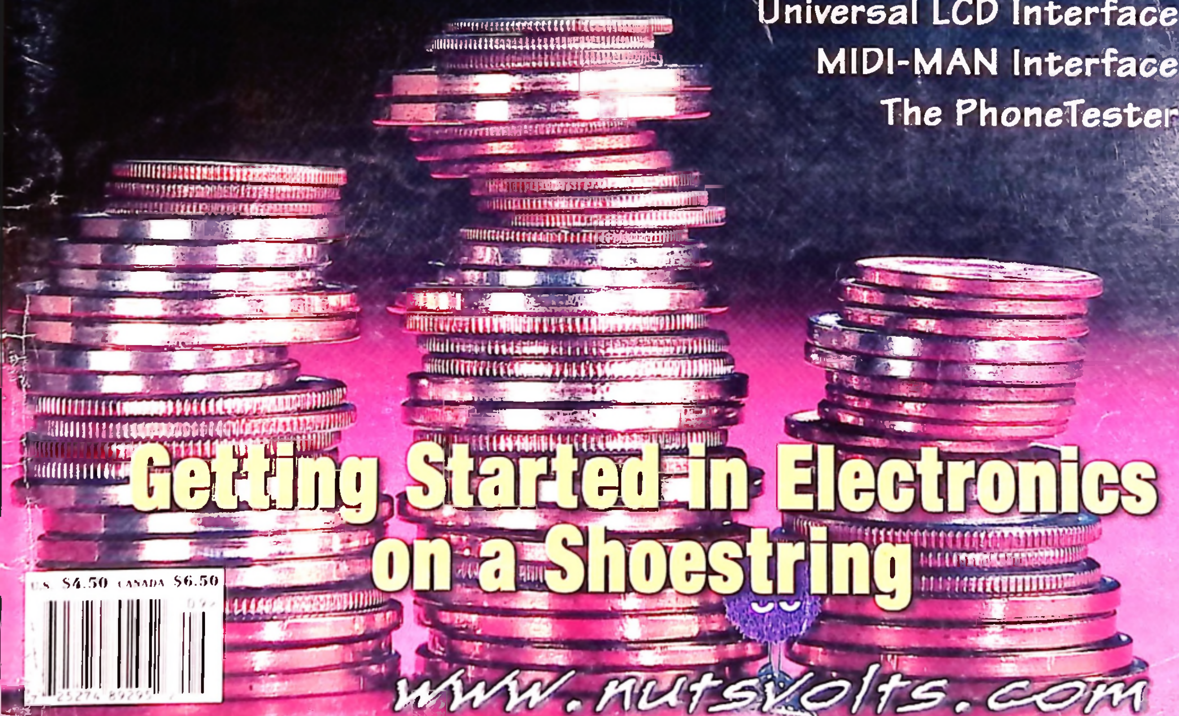

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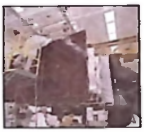

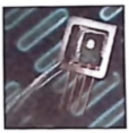

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TechKnowledgey 2001

Events, Advances, and News From the Electronics World

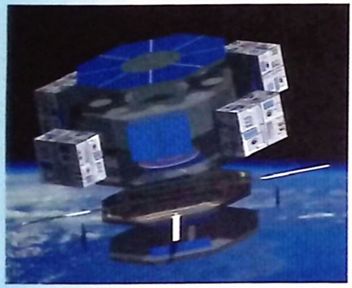
by Jeff Eckert

Advanced Technologies

MEMS Coming of Age

Miniaturization is not a new concept in electronics. The trend became apparent in the 1950s, when the first transistor radios hit the market. But more recently, engineers have started to think in terms of combining micro-scale electronic and mechanical devices to create a new technological class. This has come to be known as the science of "microelectromechanical systems" (MEMS), and it promises to provide reductions in size, weight, and power consumption ranging from 1/10 to 1/1,000.

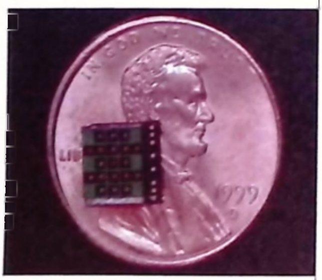
Implementation involves existing microelectronics technologies, as well as emerging processes such as microphotolithography, thin film deposition and patterning, precision etching and electroplating, and other techniques that are usually applied to IC manufacture. The definition also includes microfluidic tools such as microvalves, micro-propulsion nozzles, and tiny fluid transport systems.



Artist's conception of an orbiting nanosatellite, courtesy of The Aerospace Corp.

An important application is in small satellites, which tend to be classified by weight. Picosats weigh <1 kg, nanosats (see figure) range from 1 to 10 kg, and microsats weigh 10 to 100 kg. Still in the planning stages are femosats, which would weigh <0.1 kg.

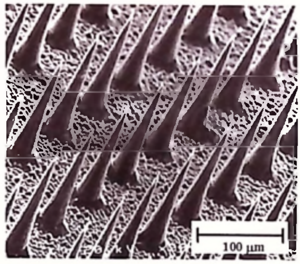
As an example of a MEMS device for satellite applications, a micro-thruster array measuring one-quarter of the size of a penny has been developed by TRW (www.trw.com) for use on micro-, nano-, and pico-satellites, and it has already passed a functionality test aboard a Scorpius sub-orbital sounding rocket. Individual microelectromechanical system (MEMS) thrusters — each a poppy seed-sized cell fueled with lead styphnate propellant — fired more than 20 times at one-second intervals during a test staged earlier this year at the White Sands Missile Range. Each thruster delivered 10^{-4} Newton seconds of impulse.



The TRW Digital Micro-Thruster chip is designed to provide "digital propulsion" to small satellites. Courtesy of TRW, Inc., Space and Electronics division.

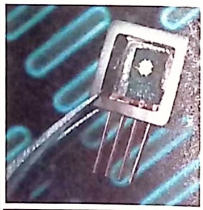
The MEMS design, based on silicon chip fabrication technology, has no moving parts; utilizes a variety of propellants; is scalable; eliminates the need for tanks, fuel lines, and valves; and fully integrates the structure of the satellite with the propulsion to power it. The micro-thruster was developed by TRW along with teammates Caltech and the Aerospace Corp., under a contract from the Defense Advanced Research Projects Agency.

Another interesting MEMS application, developed at the Georgia Institute of Technology (www.gatech.edu/), is aimed at medical applications.



This array of needles is designed for painless transdermal drug delivery. Courtesy of Georgia Institute of Technology.

Transdermal drug delivery is limited by the extraordinary barrier properties of the outer 10 to 15 mm of skin (stratum corneum). Conventional needles inserted across this barrier and into deeper tissue effectively deliver drugs, but can cause infection and pain. To create painless needles, Georgia Tech researchers Devin McAllister, Sudhasinee Smitra, S. Henry, and Mark G. Allen have microfabricated arrays of very short microneedles that are long enough to penetrate through the stratum corneum, but short enough to avoid stimulating nerves that lie in deeper tissue. According to the developers, they are mechanically strong, able to increase transdermal transport by more than four orders of magnitude, in vitro, and do not cause pain in human subjects.



A micromechanical condenser microphone. Courtesy of Draper Labs.

Finally, in the area of non-inertial micromechanical devices, Draper Labs (**www.draper.com/**) has developed silicon micromachined condenser microphones that are implemented on a single chip with integral buffer amplification. Draper has conducted fundamental research and development of units that detect low frequencies (20 Hz to 5 kHz), as well as highly sensitive arrays of sensors for high frequencies (0.5 to 2.0 MHz). Micro-level chemical sensors and optical devices are also under development.

Computers and Networking

Windows® XP Coming in October

As of the last report from Microsoft (**www.microsoft.com**), the new Windows XP operating system is still on track for release in October, despite reservations expressed by the US Congress, many privacy groups, and some of the half million users who tested a preliminary version. The system initially included a "Smart Tags" feature designed to recognize keywords in accessed documents and steer you toward related Web sites. Many beta test participants found the feature annoying, particularly because it mostly suggested web sites operated by Microsoft and its business partners. As a result, the Smart Tags will be removed from systems bought directly from Microsoft.

In addition, a complaint has been filed with the Federal Trade Commission, by Junkbusters Corp. (**www.junkbusters.com**), the Privacy Foundation (**www.privacyfoundation.org**), and a dozen other organizations about Windows XP features that collect ("Passport" and "Wallet") and distribute ("HailStorm") personal information about users. (You can download a PDF version of the 20-page document from **www.epic.org/privacy/consumer/ms_complaint.pdf.**)

According to the complaint, "Microsoft has engaged in and is engaging in unfair and deceptive trade practices intended to profile, track, and monitor millions of Internet users." Existing web browsers use "cookies" to accomplish such things in a modest way, but the data is stored on your machine and can be readily deleted (Netscape users, for example, can just trash the MagicCookie file). The Passport system, however, stores personal information — including passwords — on Microsoft servers where they cannot be deleted by users. But don't worry. Microsoft representatives have promised not to use the information without your approval. And you do trust Microsoft. Don't you?

Free Access to IEEE 802 Networking Documents

The Institute of Electrical and Electronics Engineers Standards Association (IEEE-SA) has launched what it calls the "Get IEEE 802™" pilot program, which grants public access to view and download individual electronic versions of IEEE Local and Metropolitan Area Network (802) standards. This is said to be the first time the IEEE-SA has made a series of standards widely available at no charge.

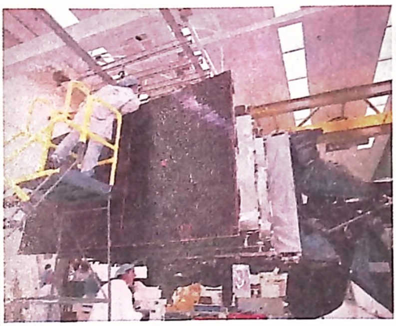
IEEE 802® connectivity is a fairly low-cost concept, and the price of the printed standards alone could exceed the cost of implementation in hardware and software for some users. Therefore, in an apparent desire to make the specifications as widely available as possible, the IEEE-SA is offering free Acrobat PDF versions, which will be available six months after a particular standard's initial publication date. New IEEE 802 standards will be added to the program with this time delay.

There are approximately 50 IEEE 802 LAN/MAN standards at present. To view and download the files, you just need to visit **http://standards.ieee.org/getieee802/**.

Circuits and Devices

The Dawn of Digital Radio

In the good old days, television was bland and limited to three networks, but at least it was free. Now most of us pay substantial monthly fees for cable or satellite broadcasts that (usually) provide better reception and offer a much wider variety of bland programs. We are still accustomed to free radio broadcasts, but by now you should be feeling the winds of change in that area, as well.



One of two telescoping solar wings aboard "Roll," a Boeing 702 satellite built for XM Satellite Radio. The 9,800-pound, 18 kW spacecraft generates 3,000 W of RF power. Courtesy of Boeing Satellite Systems, Inc.

On the transmission end, two satellite radio service providers are almost ready to get started. XM Satellite Radio, Inc. (www.xmradio.com/) and Sirius Satellite Radio, Inc. (www.siriusradio.com/) will bring you 100 channels of music, news, weather, sports, etc., for, respectively, $9.95 and $12.95 per month. Broadcasts will be offered in English plus Spanish, Mandarin, Cantonese, Hindi, and Japanese, and perhaps others in the future. Both systems use geosynchronous satellites and terrestrial repeaters to beam the signals to you.

On the receiver end, you will need a digital radio that picks up signals in the 2,320 to 2,345 MHz range. The receivers use short external antennas and resemble existing AM-FM car and table radios, but include some circuits that authenticate you as a paid subscriber. They also will cost a bit more.

For example, Pioneer will offer two add-on tuners that can be fitted to your existing radio for $199.00 and $249.00, depending on whether you want a digital display and remote control. A complete receiver/tuner package will run $399.00. Other units will cost up to $1,200.00, depending on the options selected (tape deck, CD player, etc.). Digital transmissions are scheduled to begin this fall, and receivers (which will also be available from Alpine, Jensen, Kenwood, Panasonic, and Sony, among others) should be on sale in time for Christmas.

Industry and the Profession

Worldwide Computer Sales Fall

According to market analysis company IDC (www.idc.com), the worldwide PC market was stagnant in the second quarter of 2001, and sales for the year may decline for the first time in the history of the personal computer. Shipments totaled 29,783,000 units, as compared with 30,383,000 during the same period in 2000, for an overall decline of two percent. The picture was even worse in the US, where Q2 shipments in 2000 and 2001 were, respectively, 11,426,000 and 10,501,000, for a drop of 8.1 percent. The only major computer company showing a gain was Dell, with worldwide unit sales increasing from 3,459,000 to 3,979,000, for a 15 percent increase. (Earlier this year, Dell became the number one PC manufacturer, taking the title away from Compaq.) Major losers included Compaq (down 10.5 percent), IBM (down 5.6 percent), and Hewlett-Packard (down 8.6 percent). IDC predicts that the PC market will be flat to negative for at least the rest of the year.

With computer prices dropping faster than unit sales, profits also have been widely dismal so far this year. In July, Compaq reported a $279 million quarterly loss on $8.5 billion in revenues, including a $493 million restructuring cost. This compares unfavorably with the company's $388 million profit on $10.1 billion in revenues during the same quarter of 2000. Compaq is predicting a further decline in the third quarter.

Similarly, Hewlett-Packard's revenues have dropped, and it is now predicting third-quarter revenues of about $10 billion, which is off about 15 percent from last year's $11.8 billion level. HP laid off 1,700 workers in January, another 3,000 in April, and has announced plans to let another 6,000 go by the end of the year. In addition some 80,000 employees have accepted pay cuts and unpaid vacations.

Apple Computer managed to stay in the black, with a net profit of $61 million for the quarter that ended June 30, on revenues of $1.5 billion. However, this represents a decline from $200 million from revenues of 1.8 billion. The company shipped 827,000 Macintosh® computers during the quarter.

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XYLOTRON II

Thanks for the Memory

by Robert Lang

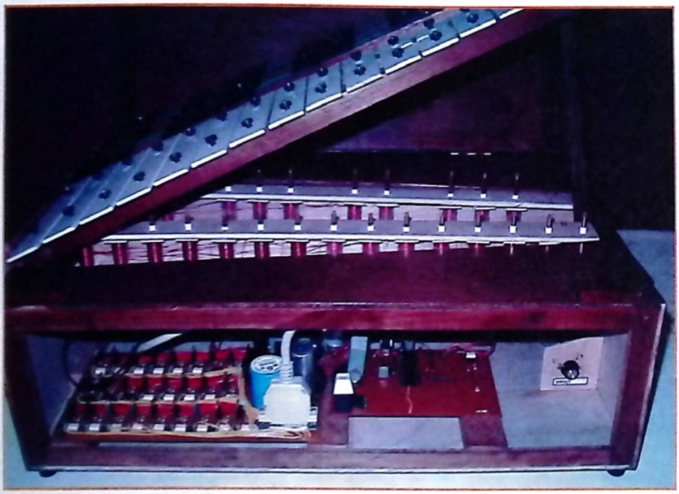

Figure 1. Original XYLOTRON Design

INTRODUCTION

Since publishing the XYLOTRON article in the Oct. 2000 issue of *Nuts & Volts*, the XYLOTRON circuitry has been used to MIDI enable and automate a number of musical instruments including a harpsichord, a calliope, and a pipe organ. Several people have asked me whether the XYLOTRON circuitry from Reference 1 can play music if not connected to a computer.

The original XYLOTRON design shown in Figure 1 did not have the ability to play music unless it was connected to a computer and MIDI data was being downloaded in real time. After lugging a computer around to several demonstrations, I came to the conclusion that the XYLOTRON should have a computer-independent mode of operation.

This article will discuss the circuit and software modifications necessary to give the XYLOTRON the ability to "hear" a MIDI tune one time and remember it, and play it on command without being connected to a computer. This article also provides some useful information on interfacing large external memory chips to a microcontroller.

HARDWARE CHANGES

There were no changes to the solenoids or solenoid driver board as described in Reference 1. All the changes were made on the microcontroller circuit board. The hardware changes to the XYLOTRON consisted of some rewiring, the addition of a serial EEPROM, and two input switches to control the mode of operation as shown in Table 1. The total cost was less than $5.00. The modified schematic for the XYLOTRON II is shown in Figure 2.

The EEPROM is electrically erasable memory that does not lose its information when the power is turned off. The EEPROM chosen was the 24LC256 from Microchip. It stores 32k bytes of information. It uses the two wire inter-integrated circuit (I2C) serial interface with a maximum clock frequency of 400 kHz. It has a 5ms maximum write cycle time for up to 64 byte pages. The 24LC256 data retention is greater than 200 years and it is guaranteed for 100,000 erase/write cycles. It is all conveniently packaged in an eight-pin PDIP package.

The addition of the EEPROM was done using the I2C pins on the Microchip 16F877 microcontroller. Unfortunately, in the original design these pins (18 and 23) were being used as note output pins. The new software redirected these outputs to pins 2 and 3 on the 16F877. The previously unused I/O pins 5 and 6 on the 16F877 were used as inputs on the new design. I/O pin A2 (pin 4) was used to control an LED that indicated when the real time clock was running. The RTC only runs when the XYLOTRON is reading or writing to the EEPROM.

Figure 3 shows the prototype of the XYLOTRON II on a breadboard. Figure 4 shows the modified XYLOTRON board with the hardware changes necessary to make it a XYLOTRON II. The hardware modifications allowed the XYLOTRON II to remember about 65,635/96=683 seconds of music or 32726/8=4090 notes, whichever comes first, using a 32K byte serial EEPROM chip. Each note required eight bytes of storage: four bytes for the NOTEON and four bytes for the NOTEOFF. The format is given in Table 2. The only MIDI information stored in the EEPROM is NOTEON and NOTEOFF. Table 3 is a list of the parts needed to create the XYLOTRON II.

SOFTWARE CHANGES

The major changes in the XYLOTRON software were the changing from a polling system to an interrupt driven system and the adding of the software to service the external memory. The source coding for the XYLOTRON II is written in Microchip assembly language and the commented source is available for free download from Reference 3. If you don't want to do the chip programming yourself, preprogrammed 16F877 chips are also available at Reference 3.

During the busiest time — MODE=1 — the XYLOTRON may be running three time critical processes. The first process is the update of

REFERENCES/SOURCES

Reference 1. October 2000 issue of ***Nuts & Volts*** for the original XYLOTRON article.

Reference 2. Microchip Application Note #735 by Richard Fischer for information on interfacing memory chips to Microchip microprocessors using I2C.

Reference 3. XYLOTRON web page **http://www2.netdoor.com/~rlang/xylotron/xylotron.htm** for software and preprogrammed 16F877 microprocessors.

Reference 4. Microchip Web Page **www.microchip.com**

Reference 5. Peter Anderson at **www.phanderson.com** for microprocessors and memory.

Reference 6. Electronix Express at **www.elexp.com** for electronic parts.

Reference 7. Jameco, Inc., at **http://www.jameco.com** for electronic parts.

the real time clock (RTC). The tick counter is incremented once every 1/96 second. This is accomplished by using the TIMER0 of the 16F877. The input to the TIMER0 is FOSC/4/PRESCALER. With a FOSC of 20 MHz and PRESCALER=256, the update frequency is 19531/sec. By initializing TIMER0 to a value of 53, there will be a rollover interrupt 96 times per second.

The second critical process is the receiving of the serial MIDI data. This data is sent from the computer at the proper time to produce a note in a song. The data must be received and processed in real time. This process is also interrupt driven.

The third process is the storage of the MIDI data along with the time it is received. This allows the XYLOTRON II to remember a song and later play it back without being connected to a computer. Each of these time-critical processes will be described in some detail below.

REAL TIME CLOCK

The real time clock is enabled in MODES 1 and 2 when MIDI data is being recorded to the EEPROM or MIDI data is being played from the EEPROM. The real time clock is reset and started when the first MIDI event is received in record MODE1 or the PLAY_SONG routine is called to play the recorded song. The 16 bit real time clock counter is incremented 96 times per second via the TIMER0 interrupt. The real time clock is automatically disabled when the count reaches 65,635 or about 683 seconds.

MIDI DATA PROCESSING

A byte of MIDI data received in MODES 0-1 will cause an interrupt. The interrupt routine receives the byte. If the byte is a MIDI status byte, the mode is stored (91 is NOTEON and 81 is NOTEOFF). If the byte is a MIDI data byte and the current mode is NOTEON or NOTE-OFF, then the data byte will be stored as NOTE and the next byte will be read and stored as VELOCITY. The proper 16F877 note output line will then be activated or deactivated.

MODE	S3	S2	OPTION	Real Time Clock Interrupt	MIDI Interrupt	EEPROM
0	0	0	Don't remember MIDI, Normal power on/reset test	Disabled	Enabled	Unused
1	0	1	Do remember MIDI, Normal power on/reset test	Enabled	Enabled	Write
2	1	0	Don't remember MIDI, Play MIDI on power on/reset test	Enabled during reset test	Disabled	Read
3	1	1	Dump EEPROM contents at 9600 BAUD. If S2 is now turned off the EEPROM is erased.	Disabled	Disabled	Read then Write

Table 1. Input Switch Setting

MIDI COMMAND	BYTE 1	BYTE2	BYTE3	BYTE4
NOTE ON	MSB of time of MIDI event. The time is units of ticks from the start of the music. 1 tick = 1/96 second	LSB of time of MIDI event	91	The MIDI note to be played, 0-FF)
NOTE OFF	MSB of time of MIDI event	LSB of time of MIDI event	81	The MIDI note to be played, 0-FF)

Table 2. EEPROM MIDI Data Storage Format

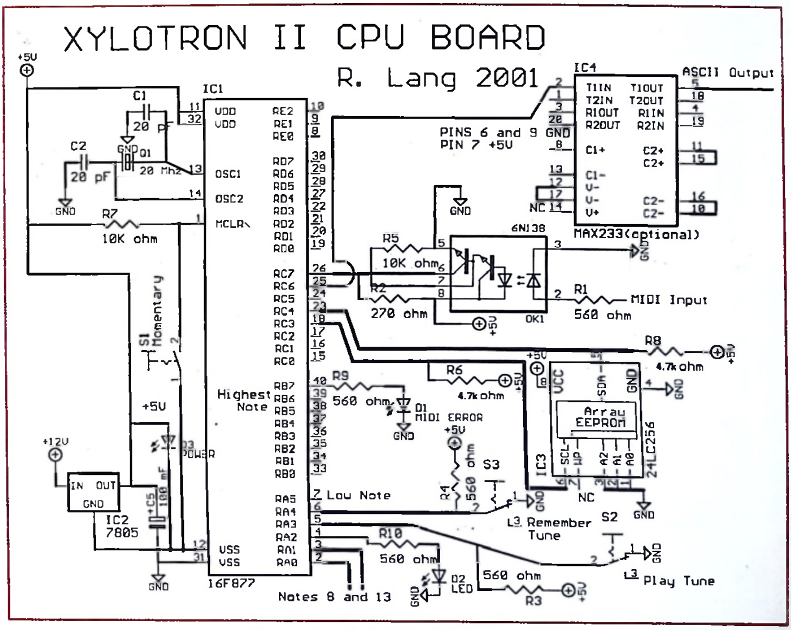

Figure 2. XYLOTRON II Schematic

MIDI DATA STORAGE/RETRIEVAL

In MODE 1 when the first byte of MIDI information is received, the real time clock is started. Next, the real time clock 16 bit value, the MIDI status byte, and the MIDI note are saved in the format shown in Table 2 in a temporary four-byte buffer area starting at address 20H. When the buffer is filled, it is written to the EEPROM. The data is transmitted serially to the EEPROM at a 400k bits/second and, upon receipt, it takes a maximum of five milliseconds to write the data.

In MODE2, data is accessed sequentially four bytes at a time starting at location 0000 in the EEPROM. The first two bytes are checked against the RTC. When they match, the next two bytes are used as the MIDI mode and note and are played. Then another four bytes are read.

PART	DESCRIPTION	SOURCE
R10,R3,R4	1/4 watt 560 ohm resistor	Reference 6
R6,R8	1/4 watt 4.7k ohm resistor	Reference 6
IC3	24LC256 EEPROM	Reference 5
S2,S3	SPST switches	Reference 6
D2	LED	Reference 6
IC4	MAX233 RS-232 Interface Chip (optional for testing)	Reference 7

Table 3. XYLOTRON II Parts List

A BUMPY START

The first task in the program development was to develop software to write and read from the external 24LC256 EEPROM. There are only two wires connecting the 24LC256 to the 16F877, so I thought this would be straightforward.

There are some application

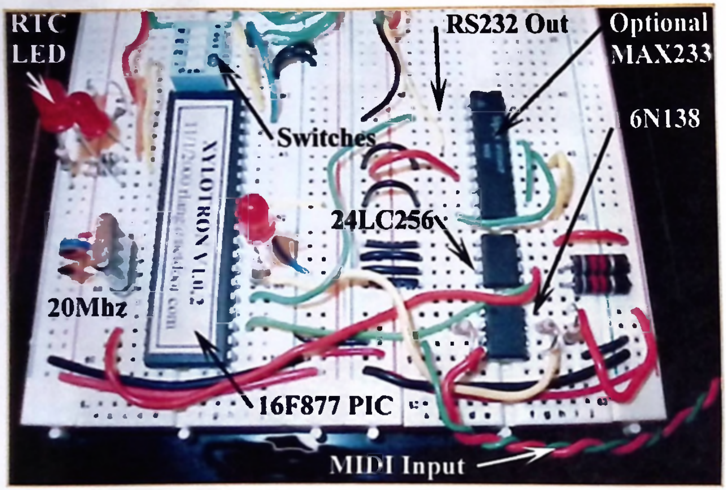

Figure 3. Prototype of the XYLOTRON II Hardware

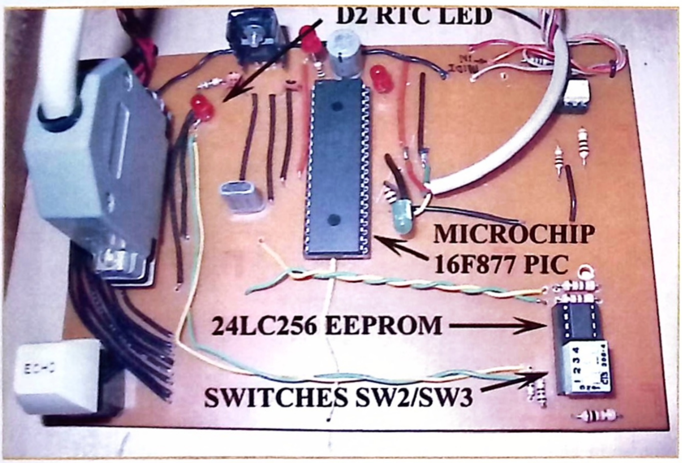

Figure 4. Completed XYLOTRON II Microcontroller Board (Modified XYLOTRON board)

```
(S2 and S3 are turned on to begin ASCII dump of EEPROM)
00 00   =00 77 91 37 00 82 81 37 00 86 91 3E 00 91 81 3E 00 95 91 37
00 95 91 38 00 A0 81 38 00 A0 81 37 00 A4 91 3E 00 AF 81 3E
00 83 91 3E 00 83 91 37 00 BE 81 37 00 BE 81 3E 00 C2 91 3E
00 CD 81 3E

00 40   =00 D1 91 37 00 DC 81 37 00 DF 91 3E 00 EB 81 3E 00 EE 91 39
00 EE 91 42 00 F9 81 42 00 FA 81 39 00 FD 91 3E 01 08 81 3E
01 0C 91 39 01 17 81 39 01 18 91 3E 01 26 81 3E 01 2A 91 3E
01 2A 91 39

(S2 is turned off to begin EEPROM
00 00   =
00 40   =
00 80   =
00 C0   =
01 00   =
01 40   =
```

Table 4. Example of MODE3 Dump of EEPROM MIDI Data

notes available for free from Microchip (Reference 4) that explain how the I2C synchronous interface to the EEPROM memory works. Unfortunately, there are so many, that it is possible to get very confused. One source of confusion is that Microchip provides technical application notes on how to implement I2C protocol in software on microcontroller chips that do not have an I2C interface module (MSSP) built in.

Another source of confusion is that the addressing scheme differs depending on the memory chip. Microchip has expanded the I2C interface specifications to allow addressing up to 2Mb. They have done this by adding an additional address byte when transmitting the address to the EEPROM. There is also confusion in how to send data to the EEPROM by using or not using interrupts.

One of the best I2C application notes is Reference 2. I followed the examples as best I could because there was no example for doing exactly what I wanted to do, which was use the MSSP hardware module on the 16F877 microcontroller to read and write data blocks to a 24LC256 EEPROM using polling. The Microchip documentation describes many ways that might work: testing the buffer full (BF) bit, testing the acknowledge received (ACKSTAT) bit, testing the receive enabled (RCEN) bit, testing the SSP interrupt flag (SSPIF), etc. For over a month, I tried all possible combinations that I could think of and got absolutely nowhere. The EEPROM would not respond.

I reviewed all the available material on the internet, contacted Microchip by email a couple of times, and posted several messages to the Microchip online discussion groups. There were many appeals for help with this same type of problem. Finally, I was beginning to think I had a faulty memory chip when I made one more email to Microchip tech support. I sent my circuit diagrams and assembly source code. I received a quick reply from Ken Dietz that included some snippets of assembly language.

Comparing his source to mine, I was able to get single byte reads and writes working and then got the block reads and writes working. It seems the key to getting the source to work was clearing and checking the SSPIF bit in the PIR1 register after each write or read even when not using interrupts. My working assembly language source is available at Reference 3 free of charge.

SETBACK #2

Once the memory problem was overcome, I had a working system. It would record and play songs with one problem. If the song was very fast, data would be lost in the record phase. The reason for this was that the EEPROM takes five milliseconds to write the data internally once it is received from the microcontroller. If an attempt is made to send more data while the internal write is in progress, it is ignored. It is important to note that it takes five milliseconds to write one byte or 64 bytes.

The solution was to implement a dual buffering system with 64 bytes in each buffer rather than the initial single four-byte buffer. One buffer is marked ACTIVE and the other is marked INACTIVE. When a MIDI input interrupt occurs, the MIDI data is written four bytes at a time to the ACTIVE buffer. When

the active buffer is filled it is marked as the FULL INACTIVE buffer and the other buffer is marked ACTIVE.

New MIDI data will now be written to the new active buffer. A background task is always checking to see if the inactive buffer is full. If the inactive buffer is full, then it is dumped to the EEPROM and then marked as EMPTY. The alternating of the active and inactive buffers continues while MIDI data is received and stored.

Since the buffer is only dumped to the EEPROM when it is filled, it may be necessary to send a few extra notes along at the end of the song to flush the contents of the buffer to the EEPROM. These extra notes will be silent as long as they are not in the active note range of the XYLOTRON. The active note range is the chromatic range from C4 through C6 or MIDI notes 48-72.

PROGRAM FLOW

When the program starts or the RESET button is pressed, the program first reads the data switches, S2 and S3, and sets the mode as shown in Table 1. In MODE0, the power on/test note sequence is played and then the MIDI interrupt is enabled. In MODE1, the power on/test note sequence is played and then the MIDI interrupt is enabled and the RTC interrupt is enabled on the receipt of the first MIDI byte. MIDI data is written to the EEPROM until it is filled or the RTC count overflows.

In MODE2, the RTC interrupt is enabled and the MIDI data is read from EEPROM and the recorded song is played. In MODE3, the MIDI data stored in EEPROM is dumped out at 9600 baud on pin 25 in the format shown in Table 4. The MIDI data shown in Table 4 corresponds to the music shown in Figure 5.

Figure 5. Musical Representation of Data in Table 4

When two notes have the same start time, then they are part of a chord. The data can be viewed on any computer with a serial port and a communications program if the optional MAX233 chip has been installed.

Viewing the contents of the EEPROM is sometimes useful in debugging. If, during the dump process, the S2 switch is turned off, the program will begin to zero the external EEPROM memory 64 bytes at a time starting at location 0000.

HOW TO USE THE NEW FUNCTIONS

In order to use the new functions, first the XYLOTRON II must be started in MODE 1 by setting switches S2 and S3 with the MIDI input connected to a source of MIDI data like a computer or MIDI keyboard. When the first note is played on the computer or MIDI keyboard, the XYLOTRON II will begin remembering all NOTEON and NOTEOFF data on MIDI channel 1. The recording will continue for 683 seconds or 4,090 notes, whichever comes first. The LED on pin 4 (D2) of the 16F877 will be lit during recording and playback indicating that the real time clock is running.

To play the recorded tune, turn the power off. Change the switch settings to MODE 2. Turn on the power and the recorded song will play. Hitting the reset switch (S1) will cause the song to restart at the beginning. Setting the switch settings to MODE 0 is equivalent to the old XYLOTRON function. Setting the switches to MODE 3 will display or erase the entire EEPROM.

CONCLUSION

With a minimum of hardware and some major software changes, the original XYLOTRON design has been improved by adding the ability to hear a MIDI tune one time, remember it, and play it on command without being connected to a computer. **NV**

Robert Lang is a professional electrical engineer interested in robots, MIDI, and music. He has written several articles for computer, electronics, and synthesizer magazines. He welcomes your comments and can be reached at ***rlang@netdoor.com.***

reader *FeedBack*

Dear Nuts & Volts:

I bought your magazine for the first time and enjoyed reading your articles. It so happens that I recently have been interested in getting more information about Op-Amps and I saw the article "Part 1 Op-Amp Basics" by Ray Marston.

In reading the article, I noticed on page 17 in Figure 10(b) that the Out=Vinx(R1+R2)/R2. But in the diagram, only resistors R3 (twice) and R1 are shown.

Would you please correct this so that I can know what is the true value of Vout. As I said, I am very much interested in knowing the right answer.

Thank you and I'm looking forward to your response.

L.Y.
Grafton, MA

Response:

This is the corrected version of the original Figure 10(b), which contained two errors.

I generated the old artwork at 3am on a cold November day last year, when I was apparently rather tired.

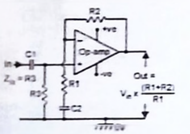

Figure 10(b). Basic non-inverting AC amplifier circuit.

Please accept my apology for the errors.

Ray Marston

Dear Nuts & Volts:

In Ron Russ' June '01 article "Building a Flash Programmer for PIC Microcontrollers," the schematic calls for a switching transistor, Q1.

What is the part number for Q1? Is this just a garden variety switching transistor?

Dave Gianna
via Internet

Response:

The transistor I use is a 2N4401A or equivalent.

Ron Russ

Dear Nuts & Volts:

Thank you for sending me a complimentary copy of your magazine.

I am one of the authors of a senior high school program called: Electricity and Electronics Technology, by Buban, Schmitt, and Carter. The program is published by Glencoe McGraw-Hill. This is the 7th edition.

The program consists of a Text, Teacher's Resource Guide, and Student Workbook.

The web site that lists our program is: www.glencoe.com. We have cited your magazine as one of several links for teachers.

I feel that teachers and their students can learn a lot from the products, articles, and other resources that your magazine provides.

Marshall L. Schmitt
Springfield, VA

Dear Nuts & Volts:

I was surprised at the answer you printed in the July '01 issue for question #6016. Not because you did not print my answer, but the text of those that you did print.

Question 6016 was "How can I convert a three-phase motor to single phase?" Answer #1 "The short answer is you can't ..." Answer #2 "Rewind it" is impractical. Depending on the horsepower, this is so simple, it surprises me that no one describes how. You simply need to connect an AC capacitor between either line to the third line to create the third phase.

The capacitor must be able to withstand the voltages involved and AC current. This method works for low HP motors, but you must experiment with the values of the capacitor so that the voltages are the same across all three lines. If the voltage is too low, then more capacity must be added. If too high, then some must be removed. Capacitors can be connected in parallel to increase capacity, or in series to increase voltage rating.

For higher HP motors, the means must be provided to switch extra capacitors into the circuit until the motor starts. This can be done with a hand- operated relay or a current relay such as those found in ordinary household refrigerators. These are called static converters because they contain no moving parts. Building a rotary converter is another story, but is very simple to do.

I have used those methods to power my machine shop since 1952 without any trouble.

The US Department of Agriculture prints a booklet describing those methods, so that should be proof that it works.

I can write many pages describing those methods and also using ordinary induction

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CLASSIFIED ADS
Natalie Sigafus

DISPLAY ADS
Mary Gamar

News Bytes

New program automatically catalogs your CD music collection without typing a thing

CD Trustee is a new Windows program that catalogs your music collection, just by inserting and removing CDs in your computer. It accesses an Internet database to gather the artist name, album title, song titles, music genre — and more — automatically. None of this information exists on a music CD. The CD Trustee program compares a unique code on the CD with an Internet database containing information on over 880,000 CDs. This database is constantly kept up-to-date, with new albums added every day.

Simply press a button that says "Add CD's Automatically." You then insert a CD in the drive and wait a few seconds while the program reads the unique code and automatically ejects that CD. You continue to insert all your CDs this way. When done, simply press another button to access the Internet, and sit back while your database is built for you. Additional data can be added manually, such as the location of the disc, your ratings, or whether you loaned it to a friend.

The entire process happens very quickly, taking only seconds per CD. You can catalog a large collection in a few hours, instead of the weeks it would take manually. You can then print reports, quickly find an artist, album, or song, or print jewel case inserts containing the list of songs. You can print cover images for insertion into a jewel case, or play a CD and have the artist, album, and song title displayed automatically.

CD Trustee is $29.95 (US), but a $10.00 discount is currently available. The program runs on computers that use Microsoft Windows. See http://www.base40.com for screen shots, to order, or to download a free trial copy.

PLCs that are programmable over the Internet

The new T100MD888+ programmable logic controller (PLC) is fully programmable over the Internet using any Java-enabled web browser. *The programming software:* Internet TRiLOGI is a client/server software suite. The client portion is a Java applet that runs off any web-browser, giving users the ability to remotely program, monitor, or control the PLC via the Internet. The server portion is any PC running the TLServer software and connects to the PLC via serial link.

Features of the T100MD888+ include eight digital inputs, eight digital outputs, and eight analog I/Os. It also has two MODBUS compatible serial ports and two 10A PWM outputs. The built-in 14-in LCD port is compatible with most LCD modules up to 4 lines x 20 characters.

The PLC is programmed using a unique LADDER + BASIC language which combines the relay-ladder logic language common in most industrial PLCs with a BASIC language interpreter to handle math with ease.

Unit selling price of the T100MD888 is $199.00. The Starter Kit that includes the Internet PLC, the TRiLOGI software, and the programming cable sells for around $259.00

Contact Triangle Research International, Inc., for more detail at:
1101 S. Winchester Blvd., J215
San Jose CA 95128,
Tel: (877) 689-3245
Fax: (530) 327-6609
Email: sales@tri-plc.com
www.tri-plc.com

NV

READER FEEDBACK CONTINUED ...

motors like found in a washing machine into 110V AC generators.

Francis Hillibush
Ringtown, PA

Dear Nuts & Volts:

I really liked Ed Driscoll, Jr.'s "Raiders of the Lost Mainframes." It's not easy to be bright and funny in an electronics article. He was.

It was fun. Hold on to him!

Travis Hardin
via Internet

Dear Nuts & Volts:

I was delighted by the very informative article "Raiders of the Lost Mainframes, Silicon Valley's Computer History Center" in your July '01 issue.

Please inform your readers that whereas The Computer History Center is probably the largest and best-funded computer museum, there are several other computer museums run by knowledgeable and dedicated volunteers that collect, preserve, and refurbish old computers for public display and historical research.

In New England, for example, there are the Rhode Island Computer Museum in North Kingston, RI (see www.osfn.org/ricm), and the RetroComputing Society of Rhode Island in Providence, RI (see www.osfn.org/rcs). Please stop by their websites and, when in New England, stop by for a visit.

Geoffrey Rochat
via Internet

by Jan Axelson

Boarding the Universal Serial Bus: Pick the Solution that Fits Your Project

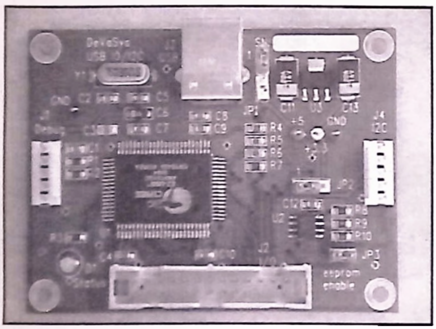


Figure 1. The USBI2CIO board from DeVaSys has everything you need to monitor and control 20 input/output bits via a USB port.

If you're designing something that will connect to a PC, chances are you'll consider using the Universal Serial Bus (USB). USB ports have been standard on new PCs for several years now, and the "legacy" serial and parallel ports that you could always count on in the past are beginning to disappear.

There are many ways to get a USB device up and running. In this article, I'll show three ways to add USB to a project. Each is best suited for a particular situation, so you can select the one that best fits your needs, skills, and budget.

I Just Want to Do a Little I/O

If your needs are basic, the USBI2CIO board from DeVaSys (Figure 1) is a ready-made solution that gives you 20 bits that you can use as inputs or outputs in any combination. The bits are standard 5V digital logic that can interface to switches, relay controls, LEDs, or other circuits. Windows applications can read and write to the bits. There's also an I2C serial interface that connects to an on-board serial EEPROM.

For the PC side of the link, DeVaSys provides several files, including a Windows device driver that is the link between the applications you write and the low-level drivers that control communications on the bus.

To read and write to the ports, the device driver supports the functions ReadIoPorts and WriteIoPorts. In my tests of the board in a compiled Visual Basic 6 application, each read or write of the 20 I/O bits took about four milliseconds, which works out to 250 reads or writes per second. This is plenty fast for many projects.

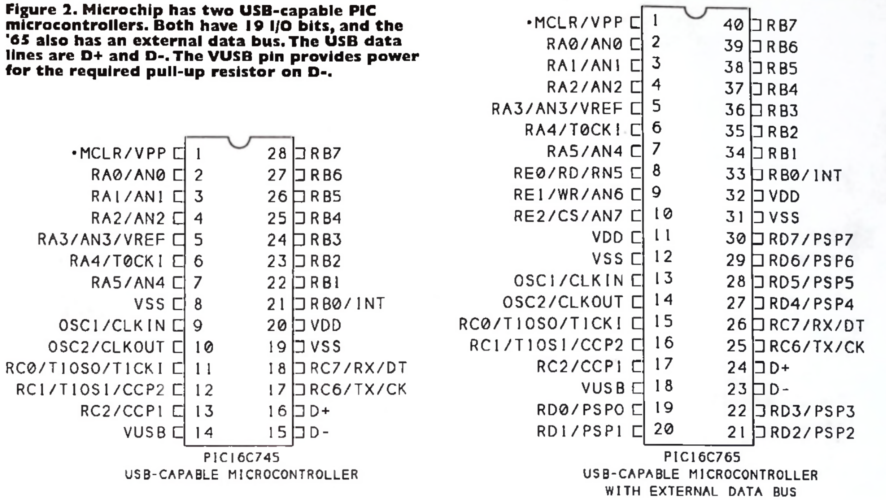
You can add other chips to the board's I2C bus. For example, Philips Semiconductor's PCF8574 remote eight-bit I/O expander has an I2C interface and eight bits of parallel I/O. You can control this and other I2C chips with the driver's ReadI2c and WriteI2c functions.

DeVaSys' website has example applications in Visual Basic and Visual C++ and a schematic of the board. The USB controller on the board is a Cypress AN2131 EZ-USB. The EZ-USB is an enhanced, 8051-compatible microcontroller with a full-speed USB interface. The board's 16-kilobyte I2C EEPROM (a 24LC128) can store program code or data. The 3.3V regulator can receive power from the bus or an external 5V supply.

As shipped, the board contains no program code. Instead, the provided device driver uses the EZ-USB's ability to receive program code from the PC when the board attaches to the PC or the PC boots. This makes updates very easy because there are no EPROMs to program.

The board isn't limited to using the driver and device code that come with it. You can write your own program code and use other device drivers, including drivers provided with Windows. The EZ-USB chips are fast, flexible, and very capa-

Figure 2. Microchip has two USB-capable PIC microcontrollers. Both have 19 I/O bits, and the '65 also has an external data bus. The USB data lines are D+ and D-. The VUSB pin provides power for the required pull-up resistor on D-.



ble. They even have two UARTs for RS-232 or similar links. Because of the support built into the chips, the amount of code you need to add for USB communications is less than what other chips require. A free assembler and a trial version of a C compiler are available from Cypress, along with complete documentation and sample code.

I Like PICs!

Microchip's PIC controllers are popular for good reason. They're inexpensive, easily available, and Microchip offers a variant for just about any purpose. Now there are two PICs that support USB: the PIC16C745 and PIC16C765 (Figure 2).

Both chips support USB's low speed. In the world of USB, low speed means a bus rate of 1.5 megabits per second, rather than full speed's 12 megabits per second or USB 2.0's new high speed of 480 megabits per second. To keep a single device from clogging the bus, the USB specification also limits the amount of bus time a low-speed device can reserve. At most, you can count on transferring 800 bytes per second in each direction.

The most popular use for low speed is devices in the human interface device (HID) class. HIDs include mice, keyboards, and joysticks, but you can also use the HID class for devices that don't fit into one of these categories. Windows includes drivers for HID communications, so if the code in your device meets the requirements of the HID spec, you don't have to provide a driver.

The PICs are enhanced members of Microchip's 16C5x series. Code written for the 16C5x is portable to the 16C7x5. Besides the USB interface, the chips have 19 I/O pins, plus the '65 has an eight-bit parallel slave port for connecting to a microcontroller with an external data bus. Up to eight of the I/O pins can function as inputs to an on-chip analog-to-digital converter.

An on-chip USART supports two other kinds of serial links. With Maxim Semiconductor's MAX232 or a similar chip, you can use the USART for RS-232 communications. The USART also supports synchronous communications, where the interface includes a clock line. Either the PIC or an external source can provide the clock.

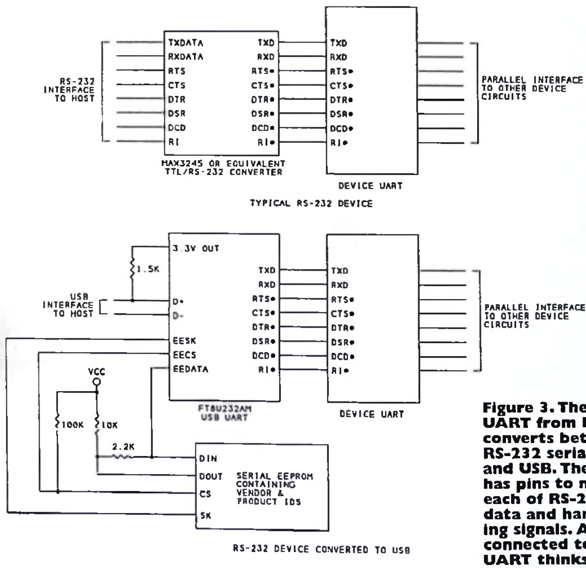


Figure 3. The USB UART from FTDI converts between RS-232 serial data and USB. The chip has pins to match each of RS-232's data and handshaking signals. A device connected to a USB UART thinks it's still communicating over RS-232.

You can use a crystal or an inexpensive ceramic resonator to clock the CPU. Program memory is EPROM or one-time-programmable (OTP) PROM. The chips are available in through-hole and surface-mount packages. Microchip's MPLAB In-Circuit Emulator (ICE) 2000 development system supports the chips.

The PICs require a fair amount of code to support USB communications, including the code that responds to the standard requests the PC sends when the device attaches to the bus. Much of this code is the same for all applications, so adapting it for a specific project requires few changes. Microchip provides code for a HID-class device that sends and receives generic data.

Other microcontroller families also have USB-capable variants. If you have experience with a microcontroller, it makes sense to stick with it when you have a project with a USB interface. Fans of the 8051 can use Cypress' EZ-USB or Infineon's

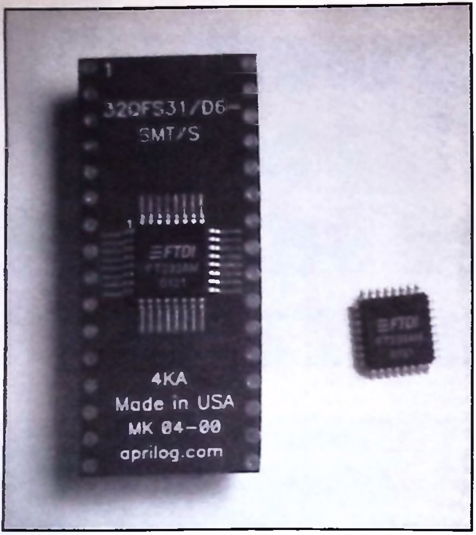


Figure 4. With an adapter, you can use the USB UART on a breadboard or a protoboard designed for through-hole components.

C541U. Atmel's AVR family includes the USB-capable AT76C711. For an eight-bit Motorola microcontroller, check out the 68HC05JB3/4 and 68HC08JB8.

I Want the Option to Use Either RS-232 or USB

The RS-232 serial port is a good, general-purpose interface that has been with the PC since its beginning. There are thousands of different RS-232 peripherals in use. But RS-232 ports are beginning to disappear from PCs. Fortunately, just about any RS-232 device can be designed to use USB, and it's easier than you might think to make a device that supports both interfaces. This way, you can use the device with everything from an old DOS PC that doesn't support USB to the latest "legacy-free" Windows PC that lacks an RS-232 port (though DOS will require different software on the PC).

An easy way to add USB capability to an RS-232 device is to buy a converter that translates between the two interfaces. A device driver included with the converter causes Windows to treat the USB device the same as if it were using a straight RS-232 connection.

With the converter option, you can use the same software on the PC to communicate with the device, no matter which interface it's using. The only limitation to using a converter is that the PC's application software must use standard Windows functions for accessing COM ports (ReadFile, WriteFile) or a custom control such as Visual Basic's MSComm, which uses these functions internally. Inp and Out functions that write directly to a port address won't work. Converters are available from many sources, including B & B Electronics, which has a large selection of USB-related items.

For a more elegant way to do the same thing, the USB UART from FTDI makes it easy to build a converter into a project.

A typical UART converts between the serial data used by RS-232 and a CPU's parallel data. Besides data lines, a UART may also support RS-232's handshaking signals such as RTS and CTS. Just about all UARTs use 5V (or 3V) logic, so converting to RS-232's positive and negative voltages requires added components, such as a MAX232 chip.

The USB UART works in a similar way to other UARTs, except instead of converting to and from parallel data, it converts to and from USB (Figure 3). To adapt an RS-232 design for USB, you move the CPU's connections from the MAX232 or other RS-232 voltage converter to the matching pins on the USB UART. The device's internal code requires no changes because the device still thinks it's talking over an RS-232 link as usual.

The USB UART supports all of RS-232's handshaking signals, and FTDI provides a free device driver.

To support both interfaces, you can include a switch that routes the signals to the RS-232 converter or the USB UART. A circuit that detects

What About USB 2.0's New High Speed?

One of the biggest news items relating to USB is its new high speed of 480 megabits per second. High speed became a possibility with the release of version 2.0 of the USB specification in 2000. Making high speed a reality requires three things: a USB 2.0 host controller in the PC, support for USB 2.0 under Windows, and a device that contains a high-speed-capable controller.

USB 2.0 host controllers will soon be standard on new motherboards, or you can add a controller to an existing system on a card that fits in a PCI slot. Microsoft has promised that support for USB 2.0 will either be included in the latest Windows edition, called Windows XP, or it will be available as an update soon afterwards. Updates for Windows 2000 and Windows Me are likely to follow. High-speed controllers for peripherals are available now from a few vendors, and the selection will increase in time.

What about all of the older, slower USB 1.x hardware? Just about all of the high-speed peripherals will also function at full speed, so they'll be usable with older hardware. And the 2.0 controllers are backwards-compatible, so all of your full- and low-speed peripherals will still work fine with the new controllers.

Jan Axelson is the author of the just-released Second Edition of USB Complete: Everything You Need to Develop Custom USB Peripherals. Visit Jan's USB Central web page at www.Lvr.com/usb.htm.

Web Links ...

Atmel USB-capable AVR controller (AT76C711) **www.atmel.com**

B & B Electronics
USB/RS-232 converters
www.bb-elec.com

Cypress Semiconductor EZ-USB
www.cypress.com

DeVaSys USBI2CIO board
www.devasys.com

DIP adapter board for FTDI USB UART
Part #32qfs31/D6-SMT/S
www.smt-adapter.com

FTDI USB UART
www.ftdichip.com/

Infineon 8051-compatible, USB-capable microcontroller (C541U)
www.infineon.com

Microchip PIC16C745 and PIC16C765
USB microcontrollers
www.microchip.com

Motorola 68HC05JB3/4 and 68HC08JB8
USB microcontrollers
www.motorola.com

Philips Semiconductor's PCF8574 Remote
8-bit I/O expander
www.philips.com

Saelig Company
U.S. distributor of the USB UART
www.saelig.com

Jan Axelson's USB Central
Tutorials, example code, and other info for USB developers
http://www.lvr.com/usb.htm

a voltage on the USB's power line could switch the signals automatically, using the USB UART when the USB voltage is present and RS-232 otherwise.

One cost of USB developing is that any product you sell must contain a Vendor ID and Product ID. When a device attaches to a PC, Windows reads this information from the chip and uses it in locating the correct device driver. Vendor IDs are assigned by the USB Implementers Forum, which is the non-profit corporation that publishes the USB specification and, in general, supports USB development. A Vendor ID costs $1,500.00 and includes the right to assign Product IDs associated with the Vendor ID.

The USB UART contains FTDI's Vendor ID and a Product ID. Because you don't change the programming in the chip, your product can use these values. You also have the option to store your own IDs in an external serial EEPROM. If you'd like a unique Product ID to use with FTDI's Vendor ID, you can request one free from FTDI.

The USB UART is a 32-lead surface-mount chip (a quad flatpack, or QFP). The chips are available in the U.S. from Saelig Company.

For experimenting on a through-hole proto board, use a DIP (dual in-line package) adapter (Figure 4), though you'll need to do some fine soldering of the chip to the adapter. One source for adapters is www.smt-adapter.com.

For another approach to USB using a different FTDI chip, see "Add a Universal Serial Bus Interface to your Next Project" by Don L Powrie in the May 2001 issue of *Nuts & Volts*. **NV**

ELECTRONICS Q&A

With TJ Byers

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.

Feel free to participate with your questions, as well as comments and suggestions.

You can reach me at:

TJBYERS@aol.com

or by snail mail at Nuts & Volts Magazine, 430 Princeland Ct., Corona, CA 92879.

What's Up:

Audio, synthesizers, music, and sounds. Lights, lamps, and dimmers. How to make your own optical RS-232 link. Making an A/V and solar connection. Finally, a reader shares a discovery.

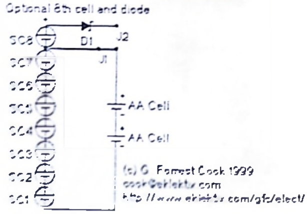
Solar Fun Site

Q I'm looking for a book about using solar cells as a power source for recharging batteries. I've looked high and low, finding all sorts of information on powering your home, but nothing at the hobby level. Do you know of anything?

Patrick Robertson, Sr.
via Internet

A As for books, all I know about are out of print, including the one I wrote 15 years ago *(20 Selected Solar Projects)*. However, there is a web site managed by G. Forrest Cook **(www.solorb.com/elect/solarcirc/index.html)** that will satisfy your appetite for hobby solar projects. Here's a sample of his work.

AA battery solar charger



Dawn To Dusk Dimmer

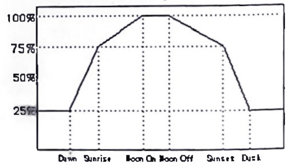
Q I am in need of information for a timer/dimmer combination. Specifically, I'm looking for a device that will control aquarium lighting: turn the light on at a very low level and increase to full brightness over a programmable period of time. Same for shutting off in the evening. This is useful for simulating the natural day-night cycle for the fish. If you know where I can obtain one in kit form, it would be most helpful. If not, schematics will do.

John A. Wass
via Internet

A AquaDirect by **AquaLink (800-827-0117; www.aquadirect.com/lighting/dimmers.html)** makes exactly what you're looking for. They also make a lunar timer that's designed to promote coral growth by simulating the lunar cycle.

Solar 1000

Dim lamps throughout the day for a natural intensity curve



Finger Pickin' Good

Q I am interested in audio electronics techniques for musical special effects — microphones and electric guitars, in particular. I have scanned back issues and found a few related articles, but I could use some more knowledge about things like reverb and wawa effects. Can you recommend any resources that would help me get started?

William Frederick, MD
via Internet

A I'd start with a couple of books on the subject, such as *Do-It-Yourself Projects for Guitarists: 35 Useful, Inexpensive Projects That Help You Unlock Your Instrument's Potential*, by Craig Anderton, $19.95.

The Stompbox Cookbook: Build Advanced Effects for Electric Guitar & Bass by Nicholas Boscorelli, $29.95.

The book by Craig Anderton is written for the beginner, while Nicholas Boscorelli's book is for the intermediate hobbyist. However, neither book has the circuits you are asking for, so I went to the Internet and discovered these web sites for understanding and building a reverb unit.

Theory

Spring reverb explained
http://members.tripod.com/~roymal/

Reverb explained
www.harmony-central.com/Effects/Articles/Reverb/

Schematics

Spring reverb schematic
http://sound.westhost.com/project34.htm

Orban 111B spring reverb schematic
www.waltzingbear.com/~audio/Schematics/Orban/111B.htm

Audio equipment schematics
www.waltzingbear.com/~audio/Schematics/Schematics.html

Construction Projects

Guitar reverb pedal
www.solorb.com/elect/reverb/

Slinky Spring Reverb
www.angelfire.com/electronic/cpeasant/projects/springs/springs.html

Kits

Craig Anderton's Hot Springs Reverb (with schematic)
www.paia.com/hotsprgs.htm

Reverb kit from Rainbow Kits
www.gatewayelex.com/kits5.htm

Parts

Reverb springs
www.vibroworld.com/parts/tech18.html
www.torresengineering.com/acrevun.html
www.cyclonemusic.com/reverb.htm

Unfortunately, I can't find any information or construction projects for the wawa sound. Seems they fell out of favor after the keyboard replaced the guitar wawa pedal. I'd start by checking around for an old Crybaby wawa pedal — try second-hand music stores.

Music Of The Spheres

Q I would like to do some experimental music synthesizer work and need your help in finding information and components to match my needs. Specifically, I want to go back in time and look at music created in the diatomic scale again (back in the days of the lap harp) using today's synthesizers or DSP chips. I know the background of this musical scale, and it doesn't match up with the chromatic scale we use today. What I need to know is how can I play with this ancient tuning method using modern-day tools.

Ennis Joseph
via Internet

A Let me lay a little background for our readers here. Before the days of Bach, most music was written for instruments like the harpsichord and flute in the diatonic scale — also known as Pythagorean tuning because of its rigid 2:1 and 3:2 music of the spheres. Check out the following web sites for background material.

Physics of Music
www.upscale.utoronto.ca/IYearLab/musicexp.pdf

The Development of Musical Tuning Systems
www.midicode.com/tunings/index.shtml

Unfortunately, this scale often meant frequent retuning of an instrument, so Bach (and others) ushered in a more tempered scale with a linear change between the notes, and some say a mellower sound. This changed the sound of music forever. But now the diatonic notes didn't match up with the new chromatic notes. The problem is that the subtle differences between true diatonic notes and the new chromatic notes are often infinite fractions, like the value of pi. So, therein lies the challenge.

If a piano made today was built around the diatonic scale, the keyboard would be about 40 keys longer — more than 100 keys. Fortunately, there are a handful of keyboards that are programmable enough to accommodate this old scale pattern. Here's a database of synthesizers, samplers, digital pianos, electronic instruments, portable keyboards, sound cards, and software synthesizers with user programmable microtonal scales or tunings.

Microtonal Synthesis
http://home.att.net/~microtonal/

But before you dip into your purse for expensive microtonal programmable, there are still a few tricks up the old sleeve (literally). The notes aren't so different that you can't trick a keyboard synthesizer into doing your bidding.

Most synthesizers and sample playback units have a way to set the tuning of each physical key on the keyboard, or of each of the 12 keys per octave, in terms of cents. (There are 100 cents per semi-tone, 1,200 cents per octave). Sometimes it's ±cents (a penny or two change from the dollar) from the 12-tone per octave equal temperament. With a little interpolation, this fudge factor can be entered fairly easily into almost any modern, digital synth's tuning table — resulting in a whole new musical vocabulary. If you're lucky enough to have a real folk harp or lyre, you can use a synth as a tuning reference to put the strings in some subset of one of these tunings. Here are the details.

Tunings for the Music of Middle-earth
www.tcinternet.net/users/jfinnamore/df/tuningsme.html

Well, the ball is now in your court. Here are two other good references that may help you become the new Bach — or Beatles — of the 21st century or the 5th.

Tuning for Beginners
www.cix.co.uk/~gbreed/start.htm

Illusion of Circular Pitch
www.illusionworks.com/html/auditory.html

Moog To MIDI

Q Do you know of a moderate audio sampling synthesizer circuit? Would you publish the schematic or steer me to a reference document? Do you know of any special interest groups that are doing work in this area?

Joseph Ennis
Valparaiso, FL

A This is a very broad question with many answers, depending on what path you take. That's because synthesizers take on many forms — there is no such thing as a generic audio sampling synthesizer. They can be audio, like the original Moog synthesizer **(http://arts.ucsc.edu/ems/music/equipment/synthesizers/analog/moog/Moog.html#901)**; digital, like modern keyboards **(SynthZone: www.synthzone.com)**; PC-based, like SoundBlaster **(www.soundblaster.com)**; or MIDI. As you can see, there is no simple answer or circuit. It depends on what technology you select, and before you can make that decision you need more facts. Here's a good place to start.

Beginner's synthesizer FAQ
http://tilt.largo.fl.us/faq/synthfull.html

Now here are some areas to do further research on the road you take. If you want to build a modern-day Moog, you can find the circuits for a DIY synthesizer at **http://machines.hyperreal.org/categories/do-it-yourself/schematics/**. For answers on MIDI, check out the following.

Computer Music
www.computer-music.com/articles/artcl001.htm

DownLinx
www.downlinx.com/proghtml/86/8695.htm

Superior S-Video

Q I recently purchased a new A/V receiver with S-Video inputs. This finally allows me to switch all my S-Video sources to my monitor. The only component in my system without an S-Video output is my VCR, which uses composite video. While the receiver handles both S-Video and composite inputs, the receiver switches them separately, which would require two cables to my monitor for seamless operation. The problem is that the monitor can only have one active input — either S-Video or composite. I figure that what I need for the VCR is a composite-to-S-Video converter so the receiver can handle everything, but these units cost over $100.00. I know the circuitry can't be that complex or expensive. Do you have a circuit available for this task?

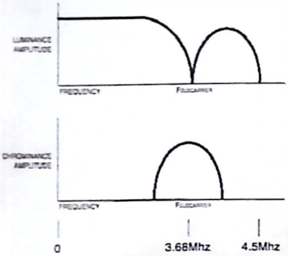
Phil Combs
via Internet

A Let me give you a little background on this before I answer, so that you can better understand my answer. All video signals are made up of four components: red video, green video, blue video, and audio. The video has two components: luminance (brightness) and chroma (color). This is generally abbreviated Y/C, where Y stands for brightness and C represents color. To broadcast this much information over a single channel, the luminance and chroma signals are encoded alongside the audio signal. This is a composite video signal, which now goes over the airways.

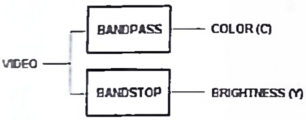
At the receiving end, these signals are decoded and sorted out. In a TV receiver there's a filter that separates the chroma from the brightness, and places it on an S-Video output, which you can now plug into your video monitor. In your VCR, the Y/C signals have been mixed and are output in composite form. This was quite popular

on older and/or cheaper VCRs before the S-Video standard became widespread. Of course, you can go under the hood of your VCR and break out the chroma and brightness signals where they go into the RF modulator, but I wouldn't recommend it unless you really know what you're doing. Which leaves us with an S-Video converter option.

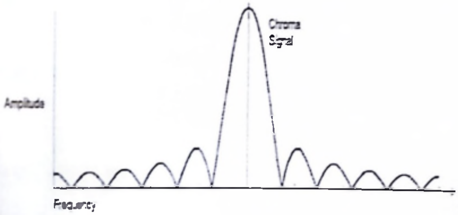
The chroma signal is located at 3.68MHz on the video bandwidth, as shown below.



To separate the chroma out, the video must pass through some kind of filtration. This is generally performed by one of two methods. In the first, the chroma is separated from the composite signal using a bandpass filter, and the brightness is separated using a bandstop filter. This can be done using passive components. These converters are inexpensive (about $40.00 to $60.00), easily installed, and require no power. (RadioShack sells them.) The disadvantage of this method is that the filter doesn't have sharp cut-off points, so brightness information that's close to that of the chroma notch is lost.



The second method is to use a comb filter. Comb filters take advantage of the fact that, generally, the luminance content of a video signal doesn't change greatly from one line to the next, so we can extract the chroma easily without sacrificing brightness detail. The technology is based on switched-capacitor technology that provides very steep cut-off points. Unfortunately, comb filter converters are active devices, which are more costly (beginning at about $130.00) and require a power source. However, the difference in improved image quality is very noticeable and well worth the extra bucks.



So, in answer to your question, it would be hard to build either type. The passive converter would be the easier, but it takes a good design with high tolerance parts. And even after that you need expensive frequency sweep instruments to tune the filters for best picture. The active converter requires a comb filter, generally an IC using switched capacitor technology, that requires several external parts. Again, it needs alignment for best picture, but this time a frequency counter will suffice. And there you have it.

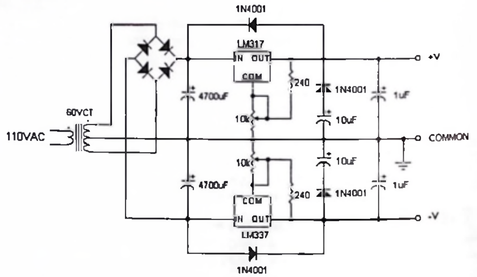
Newbie Needs Power

Q I have been an electronics hobbyist for only three months, and I am looking for a dual-polarity, dual-output power supply that can be adjustable from close to one volt to 60 volts, and have a current output anywhere from one amp to 10 amps. I am tired of building a separate power supply and spending more money for every construction project.

I tried everywhere on the web and can't find anything even remotely close to this. If you could help me with a schematic and parts list, I would really appreciate it!

Ryan Weiss
Wildwood Crest, NJ

A Well, 60 volts at 10 amps is quite a stretch, and I doubt many of your experiments will call for that kind of power. Try this circuit.



If you buy the TX-602 (60VCT @ 2A) transformer from **All Electronics (800-826-5432; www.allelectronics.com)**, this power supply will deliver a bipolar output of up to 30 volts at 1.5 amps; 60 volts at 1.5 amps if you stack them. I'm sure this will meet most of your needs. Notice that the 10k pots are dual pots; that is, they share a common shaft so that as one voltage changes, the other follows in step.

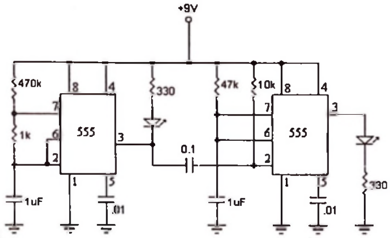
Clear The Runway

Q I'm trying to build a circuit that will flash LEDs in a pattern similar to airplane landing lights. In fact, this circuit is for an R/C airplane powered with a nine-volt battery. What I'm looking for is a timer or oscillator to flash one LED and then a second LED immediately afterwards, pause for 0.5 seconds, and then repeat. I tried using a monostable mulitivibrator, but didn't have any luck. Any suggestions?

Neil Kaufman
Silverton, OR

A Your problem was trying to match a monostable multivibrator to a task that's beyond its ability. You were right about the circuit needing a

multivibrator — but in a slave capacity. This design requires a master timing device to sync the LED flasher sequence you request. Here is your circuit.



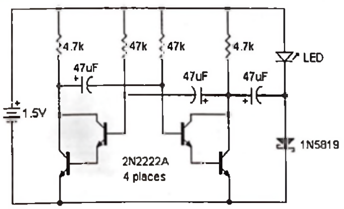
The master oscillator is a 555 astable multivibrator, which generates the 0.5-second timing needed to sequence the LEDs. First the left LED flashed which, in turn, triggers the monostable after it flashes pulses to the right LED. The two multivibrators are now reset and wait for the next bang-bang trigger. You can use a 556 — a dual 555 chip — to reduce part count and reduce aircraft weight.

LM3909 Gone, But Not Forgotten

Q I am lookin' for an LED flasher that would substitute for the obsolete, hard-to-find LM3909. It would be great if you could design a low-voltage CMOS substitute LED flasher that I could use in hard-to-reach marine markers that would be maintenance free for months.

P.M.
via Internet

A Yes, unfortunately, the next time you'll see one of these versatile oscillator chips will be next to a T. Rex exhibit. Fortunately, I keep an archive of strange circuits that I may need to call on someday, and it looks like that day for the LM3909 substitute is here. I found the circuit below in a June 1998 issue of Electronics World (a UK publication). This circuit isn't of my design, the creator is Michael Kin, but I've tested it and it works.



With the values shown, the LED flashes about 15 times a minute; the timing can be changed by altering the value of the feedback capacitors. While this makes a good low-voltage LED flasher, it doesn't have the full span of applications of the LM3909.

From RS-232 To Fiber And Back

Q I need to have an RS-232 link between two buildings located approximately 6,000 feet apart (about a mile). The only medium I'm allowed to use is fiber. I need information on building or buying an optical link that can span this distance.

WA4YOG
via Internet

A Here's a short list of suppliers who can fill your needs.

B & B Electronics
815-433-5100; www.bb-elec.com/convert_serial_port/fiber_optic.asp

JZW Control Systems
+61 2 9975 4011; www.jzw.com.au/page51.html

Omnitron Systems Technology
800-675-8410; www.omnitron-systems.com/Converters/4480view.htm

Telebyte Fiber Optic Products
800-835-3298; www.telebyteusa.com/catalog/specs/s278.htm

Versa Technology
909-591-8891; www.versatek.com/products/vlm-500.html

Versitron
800-537-2296; www.versitron.com/RS232.HTML

Reader's Hint

I came across a possibly unknown fact that may be of use to your readers. I was trying to hack together an infrared motion detector with a wireless module to make a battery-powered (portable) motion switch to trigger a camera for wildlife photography. By accident, I discovered that an X10 MS13A wireless motion detector transmits on the same frequency — and with the same code — as a RadioShack wireless door chime, Model #63-874A. (This is the model with the single remote button, not the dual buttons.) Having discovered that, it was a simple matter of wiring the chime actuator to the camera trigger. The code on the RadioShack receiver should be set to A, as it does not appear to work on codes B or C. The MS13A can be purchased separately or in the FireCracker interface kit.

Warren Shedrick
via Internet

MAILBAG

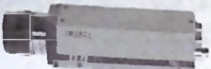
Dear TJ:

I was waiting for the errors to be corrected in later issues, but they were not. In the April 2001 issue, you told Jim Zink to tie all unused inputs to ground. This is poor advice. For TTL inputs, each input will draw between 400 uA and 1.6 mA of wasted current when tied low (TTL inputs will stay at a marginal one if left open). Most designers advise tying them high through a 2.2k or 3.3k resistor. Some designers have said to tie extra inputs together, like the fourth input of a four input gate to the third input, but this is bad practice, as well (power and speed). CMOS can be tied either way. For analog devices, it pays to read the data sheet.

In summary, the best advice is to read the data sheet. In most cases it pays to tie inputs someplace for noise reasons. But you can cause functional and power problems if you are not careful.

Steve McChrystal
Santa Clara, CA

PULNIX, INDUSTRIAL 1/2", COLOR CCD CAMERA, type TMC-7 with Pentax Lens.
Built for no compromise applications.



Specs: 1/2" CCD, 460 lines resolution, 768H x 494V Pixels, 2 lux sensitivity @f1.4, Auto/Manual AGC, Auto/Manual Shutter from 1/60 to 1/10,000 remotely controllable via 6 pin connector [illegible], Auto/Manual white balance, Manual [illegible] and [illegible] from outside the camera. Complimentary color filter. Operates on 12VDC @ 220mA. Power supply included. Also includes a high quality Pentax, 16mm f1.4 lens. A real glass lens. Standard NTSC video out on BNC connector. Y/C (S-Video) output also available on 12 pin connector supplied [illegible]. Compact size only 1.6"W x 1.25"H x 5.5" long. Perfect for use in process monitoring, surveillance, medical and [illegible]. Excellent condition, removed from inspection systems. Regular price $600
SPECIAL, PULNIX, TMC-7..........$149ea. or 2 for $249

NEW! 0.005 Lux, COLOR NIGHT VISION CAMERA! UNBELIEVABLE LOW LIGHT PERFORMANCE. State of the Art Video, Our GMV-3K, DOES it ALL!

For covert, military & scientific applications that must be color, this is it. Unbelievable 0.005Lux @ f1.2 performance is enhanced through low speed electronic shuttering, digital frame integration and advanced DSP. Auto sensitivity mode starts as it becomes dark. 24 hour surveillance is possible with the optional f1.2 auto iris lens shown below. Seven Gain/Shutter modes are user selectable. Normal, X4, X8, X16, X24, X32, X64. These provide frame rates of 60, 15, 8, 4, 3, 2 and 1 per second. Auto/Man. white balance 3200° to 10000°K, auto/man BLC, S/N >52dB, Mirror on/off, Gain on/off, auto electronic shutter 1/60 to 1/120,000 sec. Alum. housing, dual 1/4x20 mtg. Specs: 1/2" CCD, 768H X 494V, with 380K pixels, 470 Lines, 12VDC @200mA, Std. video out on BNC. Size: 51mm x 51mm x115mm long. Regulated power adapter included. All functions can be externally controlled. Use standard c-mount lens not included.
SPECIAL, GMV-3K...$449ea. High performance auto iris lens, 12mm, f1.2...$199ea.

CO2, 30Watt CW, SEALED GLASS LASER HEADS
Integral Hard Sealed Mirrors, NEW!

High quality water cooled heads. Were originally designed for medical application. Model 135, 32"L x 2.1" diam. Power requirement, 25KV trigger with 15-20KV @ 7 to 25mA operating current. These are not toys. They must conform to Class IV CDRH regulations when assembled into a functioning system. Includes state of the art, compact switching power supply. Perfect for engraving, cutting and drilling. Only two available. New Tube and Power Supply. **Limited Qty. 35Watt CO2 Package.....$995.**

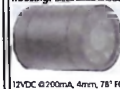
FLEXIBLE SHAFT with LEAD SCREW and "NUT"

New, 18" long flex shaft is enclosed in a 3/8" OD protective sheath. One end "Plugs" into a right angle drive which outputs the flex rotation by turning of a 1/2" diam x 7"L, 10 TPI lead screw upon which rides a 1" x1" 2"L "nut /carriage" with two 1/4 x 20 threaded holes spaced 1" apart on the long axis. Flex shafts have a 0.14" x 0.14" square drive end. You receive two complete assemblies, one with a nylon carriage and one with a steel carriage. They were originally designed to move power seats. We do not know what car. Heavy duty construction. A very interesting device. **FLEX-PAIR.........$39 / set.**

BOGEN MODEL 3232 TILT MOUNT,

Nice Italian made mount provides +/- 90 degrees of motion. Solid cast alum. construction with black powder coat finish. Industry std. reversible 1/4" x 20 or 3/8" male top mount with cork pad. Tilt base is attached to a removable 3.5"L x 2.5"W x 0.5" thick, black anodized aluminum plate via a 3/8" bolt. **BOGEN-3232......$10ea.**

WEATHERPROOF LIPSTICK CAMERA
B&W, Industrial strength, solid machined housing. Sleek black anodized, O-Ring sealed, BRASS, housing. Adjustable mount included. Specs: 1/3" CCD, 400 Lines resolution, 0.05 Lux sensitivity, AGC, Auto Shutter. Operates on 12VDC @200mA, 4mm, 78° FOV lens. A real glass lens. NTSC video out. Superior construction. SENSITIVE to IR. Ultra small Size only: 1.25" diam. X 2" long. With 60 ft. cable. Great for general outdoor use.



NEW, GM300K-N..............$99

NEW! 6.8" LCD COLOR, TFT, ACTIVE MATRIX DISPLAY, A huge 23sq. inch VIEWABLE AREA, Super Deal. 2.8X the VIEWING AREA of a 4" panel and 1.5X a 5.6" WOW!

We wish you could see the color saturation and resolution of this superior LCD display, it is fantastic. Excellent contrast ratio, high quality, full color images are comparable to a CRT. Perfect as a portable, general purpose color monitor for standard NTSC color or B&W video systems. Fully compatible with all our cameras as well as Camcorders, VCRs, DVDs etc. OEM "component" style unit has no outer cabinet. Designed to be installed in YOUR housing via four mounting tabs as shown. Specs: Resolution, 1152H x 234V, 270K Pixels! Viewing angle, Top 10°, Down 30°, Left 45°, Right 45°. Brightness, 300 nit, Size: W x H x D (mm/in), 157.2 x 122.6 x 8.0, 6.2" x 4.83" x 1.1", Weight (gm./oz.) 280 gm, 10oz. Supplied with 30" input cable. Video input via BNC jack, 12VDC input via a standard barrel connector. Regulated 12VDC @700mA power adapter included. **BRAND NEW, FIRST QUALITY. GMTFT68.......$169ea.**

NEW, LINEAR BALL SLIDES from DCI,

Three models available. The large is 6"L x 2.6"W x 1"H with 4" of travel. The medium is 5"L x 2.6"W x 1"H with 3" of travel. The small is 1.75"W x 1.75"L x 0.75"H with 1" of travel with a removable spring return for use against a micrometer or similar. Features common to all include: Solid machined aluminum with anodized construction, hardened steel ways. Slides are usable in any position and can carry heavy loads. Over 100lbs for the large and medium and 25lbs for the small. Straight line accuracy of 0.00008"/inch of travel. All are new. Limited quantity.

DCI-LONG...........$79ea.
DCI-MEDIUM.......$69ea.
DCI-SHORT..........$45ea.

PINHOLE STYLE, LIPSTICK CAMERA

Is so small you can use it almost anywhere you can imagine. Sleek black anodized, alum. housing, O-Ring sealed & RAINPROOF. Adj. tilting mount. 1/3" CCD, 380 Lines, 0.3 Lux, AGC, Auto Shutter. 9-12VDC @100mA, 4mm, f2, 90° FOV real glass lens, NTSC video. <1/2 ounce! IR SENSITIVE. 36" cable with BNC video & DC barrel jack. So tiny you can install it directly into a door. Only a 0.9" diameter hole! Size only 23mm d.x35mm long. Think of the places you could put this little jewel. **GM-200K-PH....$69ea.**

12VDC DC GEAR MOTOR, HEAVY DUTY, HIGH TORQUE, ALL METAL

These are brand new, very rugged, right angle drive, gearmotors originally intended as car window motors. They are very substantial, weighing over 2 pounds each. They offer a 0.9" diameter x 0.3"H 9 tooth steel gear drive, located centered between three 0.28" diameter cast aluminum "spider" mounting points. Each offset 120° and on a diameter of 2.5". Overall size: 3.7"W x 7.25"L x 2"H including the gear with std. automotive style 2 pin connector. Motor will operate with good torque with as little as 3VDC, normal is 12VDC @ 450mA no load with an RPM of 70/minute. Also it is of course, reversible. **WINMTR-248...$20ea. or 4 for $69**

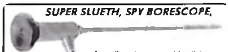
NEW! 0.01 Lux, COLOR NIGHT VISION CAMERA! FANTASTIC LOW LIGHT PERFORMANCE. Exclusive ON SCREEN, menu driven setup of all camera parameters. NEW, STATE of the ART, GMV-35KOSD,

Perfect for covert, military & scientific applications that must be color. Unbelievable 0.01Lux @ f1.2 performance is enhanced through low speed electronic shuttering, digital frame integration and advanced DSP. Auto sensitivity mode starts as it becomes dark. 24 hour surveillance is possible with the optional f1.2 lens shown below. Specs. include: Shutter speed auto or manual 1/60 to 1/120,000, 60dB S/N ratio!, 154dB Smear rejection!, AGC gain 0 dB to 18 dB to see beyond the noise merit of CCD. Digital gain 0dB to 12dB. Digital zoom continuous from up to 2X in 0.1X steps. Masking mode allows hiding 4 programmable zones for privacy protection. Camera on screen name. Choose you own name for the camera and display it on monitor for easy identification! White balance modes: Auto tracking, manual or selection from 3200k, 4800k, 5600k, 7800k, and "double white balance" independent white balance circuit for both bright and dark zone, maintains correct white balance even with combined indoor and outdoor lighting. Programmable 48 zone back light compensation mode for difficult lighting situation. Negative mode for negative film reading. Mirror image and up/down, [illegible] mounted upside down. Seven Gain/Shutter modes are user selectable. Normal, X2, X4, X8, X16, X24, X32, X64. These provide frame rates of 60, 30, 15, 8, 4, 3, 2, and 1 per second. Alum. housing, dual 1/4x20 mtg. [illegible] 1/2" CCD, [illegible] x 500H, with 4.2K pixels, 470 Lines, 12VDC @ [illegible] mA, Std. video out on BNC, [illegible] out on 4Pin connector. Size: 2"H x 2"W x 4.5" long. Regulated power adapter included. Use standard c-mount lens not included.
SPECIAL GMV-35KOSD.........$429ea.
High performance lens, 12mm, f1.2...$69ea.

A COOL COLOR CAMERA, "The ROVING EYE CAM" with Ultra Compact, 12X ZOOM, PAN and TILT AUTO IRIS and AUTO FOCUS to boot!

A super [illegible] [illegible] part of a high end [illegible] [illegible] [illegible]. The [illegible] is [illegible] [illegible] mount. There are two tiny stepper drives, which rotate 350 pan and 90 [illegible]. The tilt stepper is connected to the [illegible] board. The pan stepper is unmounted and attaches to the [illegible] or [illegible]. The camera is [illegible] via serial commands however we have no info on how to do it. Anyone who can tell us can have some free cameras. The camera module specs: 400+ lines @ [illegible]. The power required is 12VDC @ 500mA, size of head is: 5.5" diam. x 3.2"H. The [illegible] is 80° x 4L" x 1.3"H. Zoom is controlled via the serial port. No info. Composite [illegible] Y/C also. Order now, the price goes up when we get the [illegible]. Removed and individually tested for auto focus, auto iris, P&T [illegible].
SPECIAL R2D2....$99ea. or 5 for $375, NTSC or PAL avail.

SUPER SLUETH, SPY BORESCOPE,



Actually a doctor would call it an arthroscopic borescope. Super high quality medical grade, stainless, construction. Direct view eyepiece with a 6.5" long, 5mm diam. tube. Objective end optic is at a 30 degree angle for easy viewing of surrounding area. 7.5mm diam. external light port. Very Limited quantity. **Hospital Price...$800ea.**
SPECIAL......$229ea. addt'l models on web.

SUPER FAST, f1.8, 10x SURVEILLANCE LENS, unbeatable for long range observation.

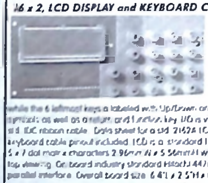
New, Fujinon, 11mm to 110mm ZOOM optics, standard C-Mount. Make any of our C-Mount cameras a long range stealth-cam! WOW! Provides 20X on a 1/3" CCD camera. Edmunds' price $800 **11-110ZM-1......$249ea.**

SUPER, MINI C-MOUNT CAMERAS, Super sensitive, GM410 or the general purpose GM412,

The GM-412 (bottom) specs: B&W, size 1.5"sq. X 2.4"L, 250,000 Pixels, 380 Lines resolution, Sensitivity 0.3 lux. The GM410 (top) specs: size only 1.5"SQ. x 1.6"L, >270,000 Pixels, 470 Lines Res., Sens. 0.05 LUX, both cameras are 1/3" CCD with AGC & Electronic shutter. 12V @110mA power. NTSC out. IR SENSITIVE. BNC video out. Both use std. DC pwr jack. Aluminum housings with dual threaded top and bottom mounting. True performance not hype! These cameras will outperform ANY camera in this magazine. Multi-lens options are available to exploit their superior performance.

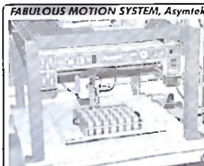
GM412, less lens..$99, GM410, less lens..$149

16 x 2, LCD DISPLAY and KEYBOARD COMBO, NICE!



A Densitron, 2162A-CT LCD module, the backlight with 18 key elastomeric keypad arranged in a 4 x 5 matrix. The rightmost 12 keys are labeled like a telephone pad while the 6 leftmost keys a labeled with Up/Down and Left/Right cursor symbols as well as a return and delete key. I/O is via a 3" long, 24 pin, std. IDC ribbon cable. Data sheet for a std. 2162A LCD module and keyboard cable pinout included. LCD is a standard 16 x 2 arrangement of 5 x 7 dot matrix characters 2.96mm W x 5.56mm H with cursor. TN type with top viewing. On board industry standard Hitachi 44780 driver with 8 bit parallel interface. Overall board size: 6.4"L x 2.5"W x 0.6"D. Viewing area 62mm W x 16.2mm H. Will really make your project look pro!
Brand New, with data. LCDKBD-2162........$5.00ea. or 10 for $4.50ea. or 100 for $3.50ea.

FABULOUS MOTION SYSTEM, Asymtek 102 series.



The Automove® 102G is a highly configurable, automatic XYZ system capable of handling a full range of applications. Wherever hand-held dispensers are currently used, automating with the 102G system will increase both accuracy and throughput. Of course the system can be configured for many other motion automation applications as well. Your imagination is the key. The system can be programmed to dispense dots or continuous lines precisely and consistently using a wide variety of fluids. This flexibility makes it ideal for applications ranging from surface mount electronics to form-in-place gasketing. The system offers several standard features: At speeds of up to 508 mm/sec (20 in /s), it provides 0.025 mm (0.001 in.) resolution with a teach accuracy of 0.025 mm (0.001 in.). It is a gantry configuration with a 457 x 457 mm (18 x 18 in.) work area. Overall size: 36"W x 28"D x 20"H. Once programmed with a personal computer, the 403G stores up to 10 separate programs in onboard memory. Features: • Programmable speeds up to 508 mm/s (20 in /s) perfect for fast, short, repetitive moves required in automated applications. • Semiautomatic part skew alignment corrects for workpiece misalignment. • Easy to use, flexible, Fluidmove® software for quick program creation is available from the manufacturer. (Not supplied) • Multiple programs can be stored in onboard memory allowing computer-free operation in a production environment. Unit is used and in excellent condition. Ships via truck. See www.asymtek.com for info.
Reg. Price >$10K, Special Asymtek 102G...$2495

SPECIAL PRICE, 350MHz, TEKTRONIX 2467, MICRO CHANNEL PLATE CRT! with 4 Channels, 500ps per div. in normal room light.

Displays intermittent variations as they happen. Captures the slowest one shot events with 4ns per division a 100 fold increase in the visual writing rate over conventional CRT. Features: 1ns rise time, 500ps/Div time base, 2mV/Div vertical sensitivity at 350MHz, 20ps time interval resolution, 1Mohm / 50 ohm input, 500MHz trigger bandwidth, four channels. On-screen waveform cursors provide vertical & horizontal scale factors, trigger level, voltage, time, freq., phase, ratio values and mode indication. With 2 probes, pouch and manual. EX. cond. 90 day warranty. **Now...$12K**

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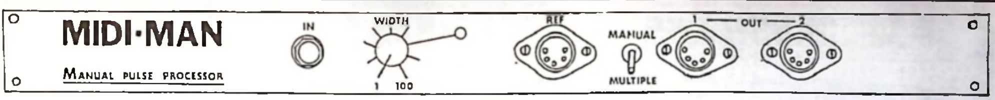


FIGURE 1: MIDI-MAN Rack Cabinet Design Layout

MIDI-MAN

by Terence Thomas

The advent of MIDI (Musical Instrument Digital Interface) has brought about a revolution in the music industry. The market is constantly being bombarded with new MIDI units all the time and these devices are incredibly sophisticated and have put a measure of control in the hands of the musician that is unprecedented. Even home studios can produce remarkably sophisticated recordings.

Despite this, manufacturers have ignored some aspects of the studio recording experience that are extremely important to the musician. If it is important to you to expand the capabilities of your home studio, then this project is for you.

MIDI-MAN

The purpose for MIDI-MAN is to provide an interface to enable the use of analog sources. So many musical instruments are not digital that some kind of interface is required, if you are to enlist the services of very important non-digital instruments. Since manufacturers do not provide such interfaces, it becomes necessary to take charge of your own destiny. This project can be the first step in your musical independence. The MIDI-MAN enables the performer to choose the best method for triggering a given sound or effect.

KEYBOARD

Some voices do not lend themselves to keyboard play; percussion instruments, for example. Drum rolls are both difficult to perform and rough on keyboard mechanisms.

With the MIDI-MAN in multiple mode, you just press a key and it will produce multiple hits. This is accomplished by the use of feedback from MIDI-MAN back to the rhythm generator in your synthesizer. The speed of the hits is determined by the number of keys you press. In fact, it is the reciprocal of the number of keys pressed, which is to say that, two keys divide the speed by two, three keys divide the speed by three, and four divide it by four, etc., etc. Drum rolls are best simulated by two keys.

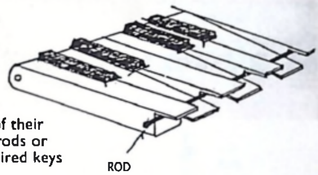
ARPEGGIOS

If pitched voices are used and more than one key is pressed, arpeggios are achieved and no matter how many keys are pressed, they will all sound. An arpeggio chart can be seen in Figure 3. Many special effects can be achieved with this technique, for example, dissonant clusters, octave modulations, and new timbre, and special effects sound generation.

TOUCH PLATE

A touch plate can be used with the keyboard to expand a player's capabilities. First, a percussion voice is selected and a key is pressed. The note will sound just once. However, if you press the touch plate while holding down keys, a perfect percussion roll will be performed. Weights placed on keys or rods used to hold down keys will free one hand for other duties while the touch plate controls play. Drummers will be interested in this method of play to enhance and accompany other percussion voices. Figure 2 shows how the rods are utilized.

FIGURE 2: Keyboard — Hold Down Rods



Almost all synthesizers have tabs at the front of their keys, so you can place rods or dowels to keep the desired keys pressed.

Parts List

- R1 - 270 ohms
- R2 - 100K
- R3 - 68K
- R4 - 15K
- R5 - 1Meg Pot
- R6 - 100K
- R7 - 330K
- R8 - 270 ohms
- R9 - 270 ohms
- R10 - 220 ohms
- R11 - 3K3
- C1 - .1 MFD
- C2 - .01 MFD
- C3 - 3,300 MFD
- Q1 - NPN Transistor 2N2222
- Q2 - NPN Transistor 2N2222
- Q3 - 5-volt regulator LM340T5
- D1 - 1N914
- D2 - 1N914
- D3 - Yellow LED
- IC1 - 4N35 Optoisolator
- IC2 - 555 Timer
- S1 - DPDT Toggle Switch
- J1 - DIN Jack
- J2 - DIN Jack
- J3 - DIN Jack
- J4 - Phone Jack

Aluminum angle pieces for the rack cabinet. Control knob, 12-volt wall transformer power supply, wire, terminal strips, circuit boards, etchant solution, 12 machine screws and bolts.

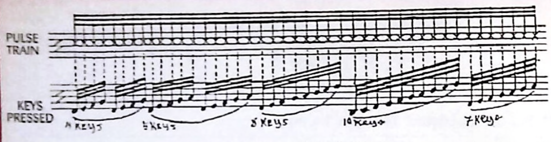


FIGURE 3: Arpeggio Chart

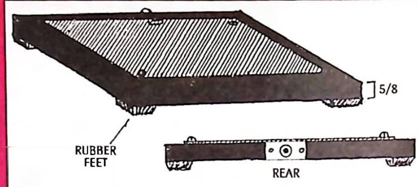


FIGURE 5: Touch Plate

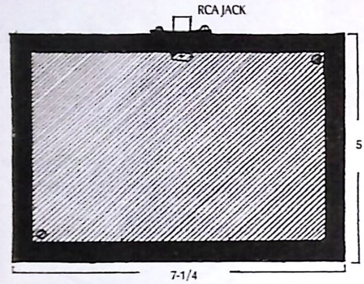


FIGURE 4: Touch Plate

Foil circuit board on press board base.

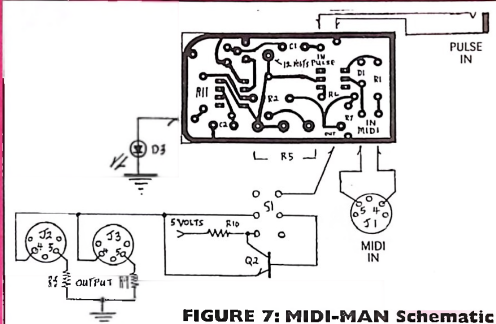


FIGURE 7: MIDI-MAN Schematic

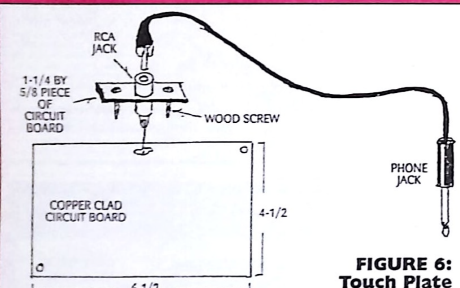


FIGURE 6: Touch Plate Wiring

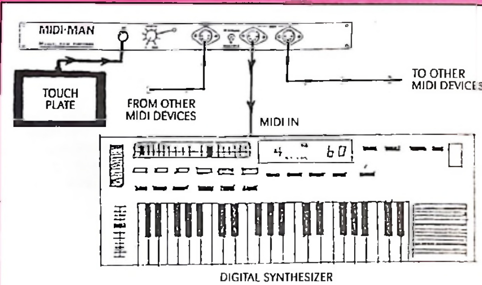


FIGURE 9: Patch Diagram

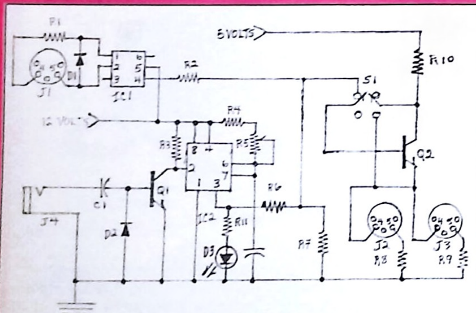


FIGURE 8: MIDI-MAN Circuit

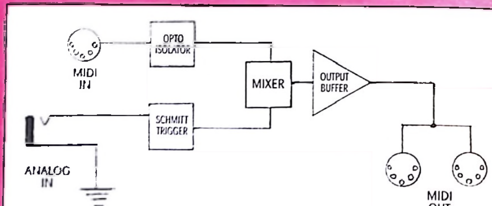


FIGURE 10: Flow Chart

The prototype was built on a 7-1/4 inch by 5-inch piece of press board, as shown in Figures 4 and 5. A 4-1/2 inch by 6-1/2 inch copper clad circuit board is used as the touch plate and is connected to an RCA type jack which is secured to the back of the press board with a small piece of circuit board that is both glued and fastened with wood screws (Figure 6).

OTHER SOURCES

Drum mikes and other electrical devices that are attached to percussion instruments can also trigger the MIDI-MAN. Pulse generators from analog synthesizers, sequencers, microphones, foot-pedal switches, light-sensitive devices, and samplers are just a few of the devices that can be used as triggering sources.

Other MIDI units can be mixed with analog devices to produce a composite triggering signal for complex rhythm coordination. Nothing is better at coordinating, synchronizing, and mixing analog and digital signals than the MIDI-MAN, and the only limit to the input possibilities is your imagination. Two outputs can feed two MIDI units for even more possibilities. To assure

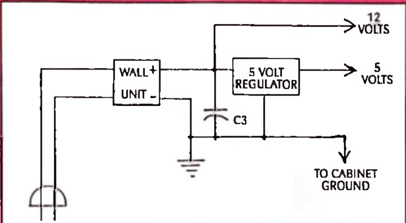


FIGURE 16: Power Supply

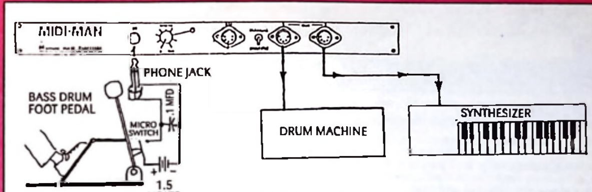
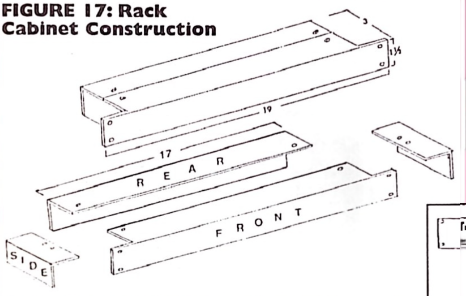


FIGURE 11: Foot Pedal Operation

FIGURE 17: Rack Cabinet Construction



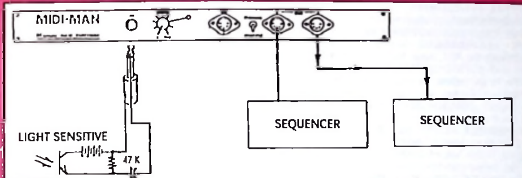


FIGURE 12: Light Source Triggering

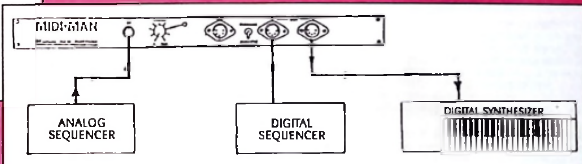


FIGURE 13: Analog Sequencer Patch

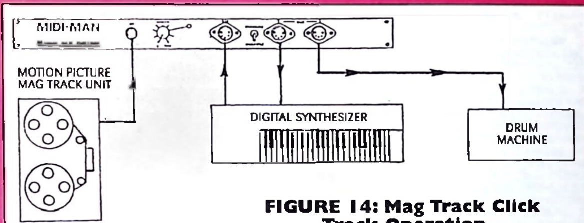


FIGURE 14: Mag Track Click Track Operation

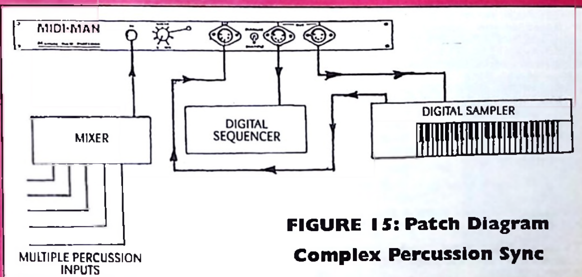


FIGURE 15: Patch Diagram Complex Percussion Sync

that you get the maximum out of this unit, you should experiment and then experiment more. After three years of using the MIDI-MAN, I have just scratched the surface.

CONSTRUCTION

The circuit in Figure 8 shows a simple, straightforward design and a foil pattern is shown in Figure 7. Input jack J4 accepts any pulse source from a fraction of a volt to 15 volts. Capacitor C1 decouples the input, while diode D2 prevents negative pulse triggering.

Transistor Q1 provides the negative pulse required for IC2, a 555 timer. Potentiometer R5 is connected directly to the circuit board and provides support and allows you to extend the pulse output to enable a single pulse to produce a number of pre-set pulses.

Output pulses are taken from pin 3 of IC2 and fed to transistor Q2 through resistor R6 and switch S1. This transistor serves as a buffer between the 12-volt operating voltage and the required 5-volt output voltage. Optoisolator IC1 accepts a MIDI signal from DIN jack J1 through resistor R1. The output of IC1 is taken from pin 4 through resistor R2 and mixed with the output of IC2, at switch S2. Resistor R7 serves as a reverse-biasing reference. A 3K3 resistor feeds a yellow analog signal monitoring LED, D3 in the prototype.

Transistor Q2 is mounted on switch S1 and provides the output signal to DIN jacks J2 and J3, through resistors R10, R8, and R9, when the switch is in the manual position. When switch S1 is in the multiple position, transistor Q2 is bypassed and the keyboard alone produces multiple hits when a key is pressed.

Power is supplied by a 12-volt wall unit with a 5-volt regulator and a patching chart, as well as a flow chart which can be seen in Figures 9 and 10, respectively.

PROFESSIONAL QUALITY

Since most of the professional studio devices come in 19-inch rack cabinets, any unit you are going to build should be in a compatible 19-inch cabinet, as shown in Figure 17.

A practical rack cabinet can be constructed inexpensively from aluminum angle molding, which can be purchased at any hardware store. Although the aluminum is thick enough — 1/8 inch — to provide a sturdy cabinet, it can be easily cut with a hack saw and drill press.

Since the cabinet is only three inches deep, it will not interfere with ventilation holes of other cabinets and does not require much ventilation itself. There is no need to include a bottom to the cabinet so you must make sure that circuit boards are insulated from cabinets mounted below ... electrical tape can serve this purpose. With proper painting and lettering, your project will look great next to the commercial units. **NV**

Events CALENDAR

SEPTEMBER 2001

September 1

CA - VACAVILLE - Hamfest. Vaca Valley RC & Western States Weak Signal Society, Larry Hogue W6OMF, 707-452-9701. Email: w6omf@cwnet.com
CANADA - ON - OTTAWA (CARP) - Hamfest. Ottawa ARC, Greg Danylchenko VE3YTZ, 613-236-9291. Email: fleamarket@oarc.net Web: http://oarc.net/fleamarket
NM - ALAMOGORDO - Hamfest. Alamogordo ARC, June Richmond K5BHE, 505-437-0298. Email: k5lrw@zianet.com Web: http://www.zianet.com/AARC/

September 1-2

CT - ENFIELD - Conference. Eastern VHF/UHF Society & North East Weak Signal, Bruce Wood N2LIV, 631-265-1015. Email: bdwood@erols.com
NC - SHELBY - Hamfest. Shelby ARC, John Ledford W4JL, 704-482-4507. Email: w4jl@shelby.net Web: http://www.shelby.net/n4fan

September 7-8

AR - MENA - Hamfest. Queen Wilhelmina State Park. 7am-5pm both days. VE testing. Queen Wilhelmina Hamfest Assn., Charlotte Lee KC5DOR, 870-642-7656 home or 870-642-2234 ext. 107 work. Email: clee1948@yahoo.com

September 7-8-9

CA - RIVERSIDE - Convention. Inland Empire Council of AR Organizations, Judy Ann Lowman W6YBS, 909-941-2367 or 909-862-1886. Email: w6ybs@juno.com
WY - LARAMIE - Hamfest. Campbell County ARC, Jay Ostrem W7CW, 307-682-7839. Email: w7cw@arrl.net Web: http://www.w7cw.vcn.com

September 8

- MELBOURNE - Hamfest. Platinum ...ist ARS, Joe Mitchell K4AW, 321-723-...85. Email: hamfest@pcars.org Web: http://www.pcars.org
IN - SPENCER - Hamfest. Owen County ARA & Bloomington ARC, Millard Qualls K9DIY, 812-332-8874. Email: w9inl@arrl.net Web: http://www.bloomingtonradio.org
KY - LOUISVILLE - Convention. Bullitt County Fairgrounds. Greater Louisville Hamfest Assn., Herbert Rowe W4WQD, 812-294-4965. Email: wd4ixl@juno.com Web: http://www.thepoint.net/~glha
MI - GRAYLING - Hamfest. ARA of Hansen Hills, Jon Schultz N8YSS, 517-348-4966. Email: jschultz@izk.net Web: http://www.arahh.org/swapshop.html
MN - RUSH CITY - Hamfest. East Central Minnesota ARC, Larry Jilek KA0MEN, 320-358-4285. Email: lj@ecenet.com
NY - BALLSTON SPA - Hamfest. Saratoga County Fairgrounds. 7am-3pm. VE testing. Talkin: 146.40/147.00, 147.84/147.24. Saratoga County RACES, Darlene Lake N2XQG, 518-587-2385
PA - BARTONSVILLE - Hamfest. Eastern PA ARA & Pocono ARK, Jerry Truax N3SEI, 570-620-9080. Email: n3sei@arrl.net
WA - GRAHAM - Hamfest. Radio Club of Tacoma, Lou Simmons KB7WDB, 253-847-5124. Email: kb7wdb@juno.com Web: http://www.w7dk.org

September 9

MA - ORANGE - Hamfest. Mohawk ARC, John Dould AE1B, 978-249-5905. Email: ae1b@gis.net
MA - SOUTH DARTMOUTH - Hamfest. Southeastern MA ARA, Tim Smith N1TI, 508-758-3600. Email: rt_smith@yahoo.com
NY - BETHPAGE - Hamfest. Long Island Mobile ARC, Ed Muro K2EPM, 516-520-9311. Email: hamfest@limarc.org Web: http://www.limarc.org
OH - FINDLAY - Hamfest. Findlay ARC, Bill Kelsey N8ET, 419-423-4604.

The Events Calendar is a free service for publicizing electronic events such as amateur radio hamfests, flea markets, etc. If your organization is sponsoring an event and would like a free listing, contact us at least 60 days in advance. Include your flyer, estimated attendance, name of the person to contact, and phone number.

Complimentary issues are available upon request for distribution to your attendees. A street address for UPS is required.

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Email: kanga@bright.net Web: http://www.bright.net/~kanga/w8ft/hamfest.html
PA - BUTLER - Western PA Section Convention. Farm Showgrounds, Roe Airport. 8am-4pm. Talkin: 147.36+. Butler County ARA, Kevin Berry KF4RMA, 724-586-1182. Email: kf4rma@arrl.net Web: http://www.qsl.net/w3udx/

September 14-15

AL - MOBILE - Hamfest. Mobile ARC, Larry Early WB4YOR, 334-342-7601. Web: http://www.angelfire.com/al/marc3

September 14-15-16

IL - PEORIA - IL State Convention. Exposition Gardens. Fri: 3pm-dark, Commercial Bldgs., Sat: 8am-4:30pm, Sun: 8am-3pm. Gates open 6am Sat & Sun. FCC testing. Talkin: 147.075+. Peoria ARC, email: w9uvi@arrl.net Web: www.w9uvi.org

September 15

AR - LITTLE ROCK - State Convention. Central AR Radio Emergency Net, Scott Derden K5SCD, 501-837-7888. Email: hamfest@carenclub.com Web: http://www.carenclub.com
AR - SILOAM SPRINGS - Hamfest. St. Mary s Catholic Church, 1996 Hwy. 412 E. 8am-3pm. Talkin: 146.67. Siloam Springs ARC, Matt Hyde N5UYK or Sherry Hyde N5UXI, 501-524-4797
GA - DALLAS - Hamfest. Paulding ARC, Bill Houston WD4LUQ, 770-445-9191. Email: bhouston@att.net Web: http://www.pauldingarc.com
IL - ROLLING MEADOWS - Convention. Holiday Inn. Northern IL DX Assn., Bill Smith W9VA, 847-945-1564. Email: w9va@aol.com Web: http://www.qth.com/w9dxcc
IN - NOBLESVILLE - Swapfest. Forest Park Pavilion. 8am-2pm. IN Historical, Mike Feldt, 317-844-0635. Email: feldtm@iquest.net
MI - CALEDONIA (GRAND RAPIDS) - Hamfest. Grand Rapids ARA, Lowell ARC, & MI AR Alliance, Ed Novakowski N8UXN, 616-458-9029. Email: hamfest@w8dc.org Web: http://www.w8dc.org
PA - SCHNECKSVILLE - Hamfest. Community Fire Co. #1. Talkin: 146.70/R (PL 151.4), 444.90/R (PL 151.4). Delaware-Lehigh ARC, Dick Dech KA3MOU, 610-837-1585. Email: ka3mou@enter.net
RI - FORESTDALE (NORTH SMITHFIELD) - Flea Market. Rhode Island Amateur FM Repeater Service, Rick Fairweather K1KYI, 401-725-7507 (7-8 PM only). Email: k1kyi@arrl.net

September 16

AK - FAIRBANKS - Hamfest. Arctic ARC, Jim Movius KL7JM, 907-452-6347. Email: ajmovius@gci.net Web: http://www.mosquitonet.com/~fbrown/01hamfest.html
CT - NEWTOWN - Hamfest. Edmond Town Hall, Rt. 6. 9am-2pm. Talkin: 146.67- PL 100. Candlewood ARA, Ken Welth KD1DD, 203-743-9181. Email: welthranch@snet.net

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Web: www.danbury.org/cara
KS - SCOTT CITY - Swapfest. Fairgrounds, 4-H Bldg., on US 83. 1pm-4pm. Sand Hills ARC, Inc., Floyd Cook, 620-872-2625 or email: fcook@odsgc.net www.odsge.net/~sharc/whatsnew.html/
MA - CAMBRIDGE - Hamfest. MIT Radio Society/Harvard Wireless Club/MIT UHF Repeater Assn., Steve Finberg W1GSL, email: w1gsl@mit.edu (Nick Altenbernd KA1MQX, 617-253-3776 9am-5pm.) Web: http://web.mit.edu/w1mx/www/swapfest.html
MI - ADRIAN - Hamfest. Lenawee County Fairgrounds. Adrian ARC, Ted Rachwal K8AQM, 517-263-0615. Email: tjrachwal@home.com Web: http://www.LNI.net/~w8tqe
OH - CINCINNATI - Hamfest. Greater Cincinnati ARA. James Weaver K8JE, 513-459-0142. Email: k8je@arrl.net Web: http://cincinnatiamateurradio.com
PA - YORK - Hamfest. York County School of Technology. VEC testing. York Hamfest Foundation, 717-764-8193. Email: w3sst@yorkhamfest.org Web: http://www.yorkhamfest.org

September 22

AR - BENTONVILLE - Hamfest. Benton County Radio Operators, Shirley 501-451-8626 or Betty 417-435-2332
CA - SANTA ROSA - Hamfest. Lewis Adult Education Center. VE session. Sonoma County RA, Inc., Rick Reiner K6ZWB, 707-575-4455. Web: http://www.cds1.net/scra
FL - NEW PORT RICHEY - Hamfest. New Port Richey Recreational Center, 6650 Van Buren Rd. 9am-3pm. Talkin: 145.35. Suncoast ARC, Owen Godwin KI4CT, 813-909-1336. Email: ki4ct@arrl.net
NE - LEXINGTON - Hamfest. Heartland Museum of Military Vehicles. Heartland ARA, Mark Voris N0VUB, home email: marvoris@nque.com or n0vub@arrl.net Work email: mvoris@krvn.com
NM - DEMING - Hamfest, tailgate only. Deming ARC, Millie Gromatzky KA7LYR, 505-544-4298. Email: kw7d@swnm.com Web: http://www.zianet.com/darc

September 22-23

IL - GRAYSLAKE - Hamfest. Lake County Fairgrounds, Rts. 45 & 120. Sat: 8am-4pm, Sun: 8am-3pm. VEC testing. Talkin: 146.16/76 (107.2 PL). Chicago FM Club, Gerald Spearman W9EG, 630-628-1501. Email: geraldspearman@msn.com Web: http://www.chicagofmclub.org
VA - VIRGINIA BEACH - Convention. Virginia Beach Pavilion. Sat: 9am-5pm, Sun: 9am-2pm. Talkin: 146.970. Tidewater Radio Conventions, Art Thiemens AA4AT, 757-484-2857. Email: thiemens@pinn.net Web: http://www.vahamfest.com

September 23

CO - LONGMONT - Hamfest. Boulder ARC, Randy Cassingham K0RCC, 303-664-5366. Email: k0rcc@thisistrue.com Web: http://www.thisistrue.com/barc.html
MD - WEST FRIENDSHIP - Hamfest. John King KB3WK, 410-465-6324. Email: kb3wk@arrl.net Web: http://www.qsl.net/cara
NJ - NORTH CROSSWICKS - Hamfest.

Delaware Valley RA, Glenn Costello N2RPM, 609-882-2240. Email: abbott0903@aol.com Web: http://www.slac.com/w2zq
OH - BEREA - Hamfest. Cuyahoga County Fairgrounds, Eastland Road Entrance. 8am-2pm. VE exams. Talkin: 146.73- PL 110.9. Hamfest Association of Cleveland, Ed Santavicca AA8TV, 800-253-3378. Email: info@hac.org Web: http://www.hac.org

September 28-29

TN - SEVIERVILLE - Hamfest. Ten-Tec, Stan Brock WD0BGS, 865-453-7172. Email: sales@tentec.com Web: http://www.tentec.com

September 29

AL - DOTHAN - Hamfest. Wiregrass ARC, Karl Davis KD4EXZ, 334-677-7485
AZ - KINGMAN - Hamfest. Hualapai ARC, Bill Beaman KA0IYS, 520-753-2293
FL - ORMOND BEACH - Hamfest. Daytona Beach ARC, John Munsey KB3GK, 907-677-8179. Email: munseyj@mindspring.com Web: http://dbara.org
MS - STARKVILLE - Hamfest. ARRL MS Section, Malcolm Keown W5XX, 601-634-3232 work, 601-636-0827 home. Email: w5xx@arrl.org
NY - HORSEHEADS - Hamfest. Chemung County Fairgrounds. 6am-3pm. FCC exams. Talkin: 146.70-, 444.20. ARA of the Southern Tier, Randy Viele N2SYT, 607-625-5893 (days) or 607-738-6857 (eves). Email: n2syt@arast.org Web http://www.arast.org

September 30

IA - WEST LIBERTY - Hamfest. Muscatine & Iowa City ARCs, Mike Hayden KB0TFT, 319-262-8790. Email: kb0tft@arrl.net Web: http://www.qsl.net/kc0aqs/hamfest.html
MD - BOWIE - Hamfest. Prince George's Stadium. VE exams. Talkin: 147.105+, 146.520 simplex. FAR, Dan Blasberg KA8YPY, 301-345-7381. Email: blasberg@bellatlantic.net
NY - YONKERS - Flea Market. Lincoln High School, Kneeland Ave. 9am-3pm. VE Exams. Talkin: 440.425 PL 156.7, 223.760 PL 67.0, 146.910, 443.350 PL 156.7. Metro 70cm Network, Otto Supliski WB2SLQ, 914-969-1053. Email: wb2slq@juno.com Web: http://www.metro70cm network.com
WA - CHEHALIS - Hamfest. Chehalis Valley ARS, Bill Harwell KC7QHJ, 360-748-8086. Email: kc7qhj@arrl.net Web: http://www.cvars.org

OCTOBER 2001

October 5-6

NH - HOPKINTON - Hamfest. HOSSTRADERS, Joe Demaso K1RQG, 207-469-3492. Email: k1rqg@aol.com Web: http://www.qsl.net/k1rqg

October 6

FL - JACKSONVILLE - Hamfest. FL Community College, North Campus, 4501 Capper Rd. 6:30-2pm. Crown Amateur Radio Convention Committee, Billy Williams N4UF, 904-765-3230. Email: n4uf@nofars.org or Willis Layfield KD4UJK, 904-765-1104, email: willis@kd4ujk.com Web: http://www.nofars.org/hamfest.htm
KS - HOLTON - Hamfest. Atchison County ARC, Joel Breakstone K1CQ, 785-945-3763. Email: joel@ksdot.org
NJ - HACKENSACK - Hamfest. Bergen ARA, James Joyce K2ZO, 201-664-6725. Email: jjjoyce@cybernex.net Web: http://www. bara.org
NY - POMPEY HILLS - Hamfest. Radio Amateurs of Greater Syracuse, 315-698-4558. Email: ragsonline@hotmail.com Web: http://www.pagesz.net/~rags
PA - LANCASTER COUNTY - Tailgate Fest. Red Rose Repeater Assn., Dave Phillips W3CWE, 717-872-6578. Email: jjcd@prodigy.net Web: http://www.qsl.net/rrra/
SC - ROCK HILL - Hamfest. York County ARS, Sheila Parrish KG4CDF, 803-328-5983. Email: coy@cetlink.net
TX - BELTON - Hamfest. Bell County Expo Center. VE testing. Talkin: 146.820- PL 123. Temple ARC, Mike LeFan WA5EQQ, 254-773-3590. Email: hamexpo@tarc.org Web:

October 7

CT - WALLINGFORD - Hamfest. Mountainside Special Event Facility, High Hill Rd., Exit 15, Rt. 91. 9am-3pm. Talkin: 147.36. Meriden ARC, Inc., email: nutmeghamfest@qsl.net Web: www.qsl.net/nutmeghamfest
IL - BEARDSTOWN - Swapmeet. UFCW Union Hall, Arenzville Rd. 8am-5pm. Talkin: 146.715. IL Valley ARC, Tim Childers, 217-245-2061, email: kb9fbl@arrl.net or Butch Tritsch KB9LZP, 217-322-2803, email: bruce@jacil.org
IL - DECATUR - Decatur Old Fashioned Hamfest, Jerry Sebok N9RBQ, 217-423-2095
IN - BEDFORD - Hamfest. Lawrence County 4H Fairgrounds. FCC testing. Talkin: 145.310. Hoosier Hills Ham Club, Jerome Kutche N9LYA, 812-849-0095. Email: n9lya@blueriver.net Web: http://www.hoosierhillshamfest.org
OH - MEDINA - Hamfest. National Guard Armory, 920 W. Lafayette Rd. 8am-2pm. VE testing. Talkin: 147.030+. Medina Two Meter Group, Mike Rubaszewski N8TZY, 330-273-1519. Email: n8tzy@m3net.net Web: http://www.qsl.net/m2m

October 10

FL - ORLANDO - Hamfest. The Bahia Shrine, 2300 Pembrook Dr. 6am-2pm. Talkin: 147.390. Larry KG4CON 407-648-8489, email: king4con@netzero.net. Alan 407-740-7817, email: albie1820@earth link.net. Ed KY4E 904-736-7770, ky4e@excite.com

October 12-13

FL - WALDO - Hamfest. The Trading Post Restaurant. Fri: 2-6pm, Sat: 8am-2pm. Talkin: 145.150. Tony 904-964-9328, email: wb2fgl@arrl.net. John, email: hamfest@ku4ay.net. Web: www.angelfire.com/fl/arcba/hamfest.html 1fyr

October 13

FL - PLANTATION - Cy Harris W4MAQ Memorial Free Flea. Motorola, 8000 W. Sunrise Blvd., Northeast parking lot. Talkin: 146.79 (-600). Robin Terrill N4HHP, 954-583-3625. Email: kg4chw@arrl.net Web: www.geocities.com/bcepn/freeflea.html
FL - STARKE - Hamfest. ARC Bradford Area, John Bradley KU4AY, 904-782-1185. Email: hamfest@ku4ay.net Web: http://ku4ay.net/starkehamfest.html
FL - TAMPA - Hamfest. Egypt Shrine Temple, Keith Dean KA4JLW, 813-879-2449. Email: kwdean@gte.net
GA - AUGUSTA - Hamfest. Evans Middle School. 9am-3pm. VE testing. Talkin: 145.490-. ARC of Augusta, Henry Arostegui KN4AV, 706-793-1625, email: kn4av@bellsouth.net or Jay KG4LEY, 706-651-9504, email: kg4ley@bellsouth.net
HI - HONOLULU - State Convention. Koolau ARC, Walt Niemczura AH6OZ, 808-263-3872. Email: ah6oz@arrl.net Web: http://www.chem.hawaii.edu/karc/
IL - SALEM - Hamfest. Centralia Wireless Assn., Daisy King AA9EK, 618-532-6606. Email: bking@accessus.net
NY - LAKE PLACID - Hamfest. Northern New York ARA, Chuck Orem KD2AJ, 518-563-6851. Email: kd2aj@arrl.net Web: http://www.geocities.com/nnyara
TN - OAK RIDGE - Hamfest. Fraternal Order of Eagles Bldg., 1650 Oak Ridge Turnpike. 9am-3pm. VE exams. Talkin: 146.88. Oak Ridge ARC, David Bower K4PZT, Email: d.bower@ieee.org
VA - STAFFORD - Hamfest. Stafford ARA, Rich Diddams KF6UTH, 540-657-8322. Email: rldiddams@earthlink.net Web: http://www.n4nw.org/Hamfest.htm
WA - BREMERTON - Hamfest. North Kitsap ARC, Susan Johnson AB7MD, 360-697-9379. Email: nkarc@yahoo.com Web: www.silverlink.net/nkarc/hamfest.html

October 14

IL - OAKBROOK TERRACE - Hamfest. Entrance at Park View Dr., north from Cermak Rd. 8am-1pm. CARC, Melissa Meneely KB9QWZ, 773-384-7514 or Dean NB9Z, 708-331-7764. Email: carc_inc@hotmail.com Web: http://www.chicagoarc.com
IN - GREENFIELD - Swapmeet. Riley Park. 7:30am-2pm. IN Historical Radio Society, Glenn Fitch, 765-565-6911, email: glenn.fitch@cnz.com
MI - DIMONDALE - Hamfest. The Summit, 9410 Davis Hwy. 8am-2pm. VE testing. Talkin: 145.390- or 146.520 simplex. Central MI ARC & Lansing Civil Defense Repeater Assn., J. Ervin Bates W8ERV, 517-676-2710. Email: w8erv@arrl.net Web: http://www.qsl.net/lcdra/hamfair.org.html
OH - ASHLAND - Hamfest. Ashland Area ARC, John McMurray KC8AAR, 419-281-3117. Email: johnamcmurray@myexcel.com
PA - WRIGHTSTOWN - Hamarama 2001. Mt. Airy VHF Radio Club (Packrats), Joe Keer W3KJ, 215-256-1464. Email: packrats_w3ccs@yahoo.com Web: http://www.ij.net/packrats

October 19-20-21

CA - CONCORD - Convention. Sheraton Hotel. Mt. Diablo ARC. Web: www.pacificon.org

October 20

CO - GOLDEN - Hamfest. Jefferson County Fairgrounds, 15200 W. 6th Ave. 8am-2pm. VE testing. Talkin: 144.62/145.22. Rocky Mountain Radio League, Inc., Ron Rose N0MQJ, 303-985-8692. Email: n0mqj@arrl.net Web: http://rmrl.hamradios.com
LA - LAKE CHARLES - Hamfest. Southwest LA ARC, Charlie Blankenship WB5NXD, 337-478-7566. Email: wb5nxd@yahoo.com
OR - RICKREALL - Hamfest. Mid-Valley ARES, Bud Smith N7BUD, 503-838-0266. Email: n7bud@arrl.net Web: www.teleport.com/~binder/swap.html
TX - DENTON - Hamfest. Denton County ARA, Clint Miller KD5BYY, 940-390-5338. Email: cmiller@dentonhamfest.org Web: http://dentonhamfest.org
TX - HOUSTON - Hamfest. Clear Lake ARC, John Taylor KD5IHO, 713-504-1403. Email: kd5iho@swbell.net Web: www.clarc.org

October 20-21

GA - ROME - Hamfest. Northwest GA ARC, Ed Byars WB5FGM, 706-235-2048. Email: biged5341@aol.com Web: www.wavegate.com/~chall/home.html

October 21

MA - CAMBRIDGE - Hamfest. MIT Radio Society/Harvard Wireless Club/MIT UHF Repeater Assn., Steve Finberg W1GSL, email: w1gsl@mit.edu (Nick Altenbernd KA1MQX, 617-253-3776 9am-5pm.) Web: http://web.mit.edu/w1mx/www/swapfest.html
MI - KALAMAZOO - Hamfest. Kalamazoo County Fairgrounds. Talkin: 147.040. Kalamazoo ARC & SW MI Amateur Radio Team, Charlie Burgstahler KB8BLO, email: charlieb@net-link.net. Web: http://www.qsl.net/k8blo/hamfest.htm
MI - WARREN - Hamfest. Utica Shelby Emergency Communication Assn., Delphine Wrona KC8JSH, 810-791-4669. Email: delwrow@att.net Web: http://www.useca.org
NY - QUEENS - Hamfest. Hall of Science parking lot, Flushing Meadow Corona Park, 47-01 111th St. VE exams. Talkin: 444.200 repeat, PL 136.5, 146.52 simplex. Hall of

Events CALENDAR

Science ARC, Inc., Steve Greenbaum WB2KDG, 718-898-5599 eves only. Email: WB2KDG@bigfoot.com
PA - SELLERSVILLE - Hamfest. Sellersville Fire House, Rt. 152. VE testing. Talkin: 145.31. RF Hill ARC, Linda Erdman KA3TJZ, 215-679-5764. Email: rfhillarc@yahoo.com Web: http://www.rfhill.ampr.org

October 26-27

OK - KINGSTON - Texoma Hamarama Assn., Len Carlson K4IWL, 972-519-0521. Email: k4iwl@arrl.net
Web: http://www.angelfire.com/tx5/TexomaHamarama/

October 27

CANADA - QUEBEC - LONGUEUIL - Hamfest. Montreal South ARC, Micheline Simard VE2XW, 450-446-0477. Email: ve2xw@amsat.org
CT - WATERFORD - Auction. Senior Citizens Center, Waterford Municipal Complex, Rt. 85. Talkin: 146.97 PL 156.7. Tri-City ARC, Darryl DelGrosso, 860-443-7799. Email: DDelgrosso@aol.com
FL - JACKSONVILLE - Hamfest. Morocco Shrine Auditorium, 3800 S. St. Johns Bluff Rd. Sat. 8am-4pm. VE exams & upgrades. Talkin: 146.76, backup 146.88. Greater Jacksonville Hamfest Assn., Richard Smythe KF4PBL, 904-739-9713. Email: rsmythe2@bellsouth.net Web: www.jacksonville.net/~lrich/JAXHAMFEST.html
MN - ST. PAUL - Hamfest. RiverCentre. 8am-4pm. VE exams. Twin Cities FM Club, Amanda Roberts KG0AY, 612-535-0637 or 651-460-6050. Email: kg0ay@pclink.com Web: http://www.hamfestmn.org
MO - ST. LOUIS - Hamfest. Kirkwood Community Center, 111 N. Geyer Rd. 7:30am-1pm. VE exams. Talkin: 146.31-.91. St. Louis ARC & Gateway to Ham Radio Club, Steve Welton W0SLW, 314-638-4959. Email: slw@partyline.net Web: http://www.halloweenhamfest.org
NM - SOCORRO - Hamfest. Socorro ARA, NM Tech ARA, & City of Socorro, Al Braun AC5BX, 505-835-3370. Email: ac5bx@juno.com Web: www.ees.nmt.edu/sara/homepage.html
SC - SUMTER - Hamfest. Sumter ARA. Carl Ecabert AA1MD, 803-469-7183. Email: aa1md@sumter.net Web: http://www.geocities.com/CapeCanaveral/2695/sara.htm
TN - EAST RIDGE (CHATTANOOGA) - Hamfest. Chattanooga ARC, Louise Carter KE4DGW, 423-821-4043. Email: ke4dgw@msn.com Web: http://www.hamfestchattanooga.com

October 28

IA - DES MOINES - Hamfest. Tikva Tracers ARC & Iowa Assn. of AR Clubs, Rod Ivers KI0BW, 515-278-9945 or 515-276-0500. Email: ki0bw@arrl.net
MD - WESTMINSTER - Hamfest. Carroll County Agricultural Center. VE session. Talkin: 145.41-. Carroll County ARC, Inc., email: k3pzn@arrl.net. web: http://www.qis.net/~k3pzn

NY - LINDENHURST - Hamfest. GSBARC & SCRC, Phil Lewis N2MUN, 631-226-0698. Email: info@gsbarc.org Web: http://www.gsbarc.org
OH - CANTON - Hamfest and Auction. Stark County Fairgrounds, 305 Wertz Ave. NW. 8am-3pm. Talkin: 147.18+. Massillon ARC, Terry Russ N8ATZ, 330-837-3091. Email: marc.hamclub@juno.com Web: http://www.qsl.net/w8np

NOVEMBER 2001

November 2-3

TX - ODESSA - Hamfest. West Texas ARC, Craig Martindale W5BU, 915-366-4521. Email: w5bu@arrl.net

November 3

FL - UMATILLA - Hamfest. Lake ARA, John Gabele W8KCE, 352-394-2723. Email: w8kce@aol.com Web: http://www.qsl.net/k4fc
OK - ENID - Hamfest. Garfield County Fairgrounds, Hoover Bldg. 8am-5pm. VE testing. Talkin: 145.29 -600, 444.400+ 5.0. Enid Hamfest Group, Tom Worth N5LWT, 580-233-8473 or Fred Selfridge WA5OU, 580-242-3551. Email: enidhamfest@yahoo.com

November 3-4

GA - LAWRENCEVILLE - State Convention. Gwinnett County Fairgrounds. Alford Memorial RC, Randy Bassett KR4NQ, 770-663-4244 xt 3989. Email: KR4NQ@bigfoot.com Web: www.totr.radio.org

November 4

IA - DAVENPORT - Hamfest. Davenport RAC, Dave Mayfield W9WRL, 309-762-6010. Email: hamfest@gwltd.com Web: http://www.w9wrl.com/hamfest
MI - ST. JOSEPH/BENTON HARBOR - Hamfest. Blossomland ARA, Duane Durflinger KX8D, 616-982-0404. Email: comdac@comdac.com Web: www.comdac.com/bara

November 10

AL - MONTGOMERY - Hamfest. AL State Fairgrounds, Garrett Coliseum, Federal Dr. 9am-3pm. CAVEC testing. Talkin: 146.84 W4AP. Montgomery ARC, Dennis Rumbley KS4UO, 334-409-9971. Email: ks4uo@arrl.net Web: http://jschool.troyst.edu/~w4ap/
FL - PORT ST. LUCIE - Hamfest. Port St. Lucie ARA, John Cruz KT4VI, 561-465-9533. Email: brothercruz@cs.com
OH - GARFIELD HEIGHTS - Hamfest. Laura Lonczak, 216-663-3258. Email: 1n4js@visn.net
OH - GEORGETOWN - Hamfest. Grant ARC, Dot Silman KB8TQU, 937-446-2234. Email: Huggee@Bright.net
SC - MYRTLE BEACH - Hamfest. Grand Strand ARC, Gordon Mooneyhan KE4HXL, 843-448-9379. Email: beachfest2001@hotmail.com Web: http://www.w4gs.org
TX - AZLE - Hamfest. Tri-County ARC, Jim Aiello N5QU, 817-444-9465. Email: drjaiello@aol.com Web: http://www.qsl.net/tcarc-ntx

November 11

IL - CHICAGO - Auction. DeVry Institute of Technology, 3300 N. Campbell. Chicago ARC, Inc., Melissa Meneely KB9QWZ, 773-384-7514 or Dean NB9Z, 708-331-7764. Email: carc_inc@hotmail.com Web: http://www.chicagoarc.com

November 16-17

MS - OCEAN SPRINGS - Hamfest. West Jackson County ARC, Emile Orman W5OXA, 228-392-2816. Email: w5oxa@arrl.net Web: http://www.datasync.com/~w5oxa

November 17-18

IN - FORT WAYNE - State Convention. Allen County War Memorial Coliseum Expo Center, 4000 Parnell Ave. Sat: 9am-4pm, Sun: 9am-3pm. Talkin: 146.88-. ACARTS, James Boyer KB9IH, 219-489-6700. Email: jboyer@ail.com Web: http://www.acarts.com

November 24

FL - OCALA - Hamfest. Booster Stadium, NE 36th Ave. 8am-2pm. Marion County, 352-236-0744 voice. Email: jtcomm@atlantic.net
IN - EVANSVILLE - Hamfest. EARS, Neil Rapp WB9VPG, 812-479-5741. Email: ears@w9ear.org Web: http://w9ear.org.hamfest.htm

November 25

IL - WHEATON - Radio Fest & Flea Market. DuPage County Fairgrounds. Fire & Radio Traders Society of Northern IL, 630-826-7981. Email: alf3148@megsinet.net

DECEMBER 2001

December 1

AZ - MESA - Hamfest. Superstition ARC, Ed Cole KB7RMO, 520-468-9015. Email: colej@cybertrails.com

December 1-2

FL - PALMETTO - Hamfest. Manatee County Convention and Civic Center, One Haben Blvd. at US41. The Florida Gulf Coast ARC, Fred Hendershot N3BUL, 813-671-9556. Email: fgcarc@fgcarc.org Web: http://www.fgcarc.org

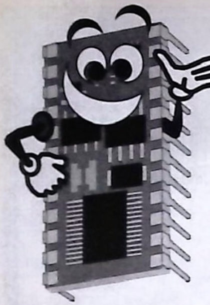
December 2

MI - HARRISON TOWNSHIP - Hamfest. L'Anse Creuse ARC, Gregg Crump KC8PXJ, 810-463-0729. Email: grcrump@home.com Web: www.ameritech.net/users/lc_arc/index.html

December 9

IN - GREENFIELD - Hamfest. Greenfield Central High School Pavilion, 810 N. Broadway St. 8am-2pm. VE testing. Talkin: 145.330-. Hancock ARC, email: kb9vzl@excite.com Web: www.w9atg.org

Circle #51 on the Reader Service Card.



by Jon Williams

Stamp Applications

TOOL TIME

Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips

My favorite BASIC Stamp peripheral is the character LCD. I love them. I have a truckload on my desk and I use them all the time. I have 2x16, 2x20, 4x20; I have just about every flavor of Scott Edwards serial LCDs. I'll say it again: I love them.

LCD REDUX

LCDs are good because they're inexpensive (downright cheap in some cases), easy to connect to the Stamp, and allow us to provide a lot of information to the outside world. Naturally, I was thrilled when I learned that the BS2p would have direct support for parallel LCDs and that the commands would work very much like **SEROUT** and **SERIN** — allowing me to use the formatting modifiers. Does it get any better than this?

I'm pretty darned sure that if comedian Tim Allen knew anything about microcontrollers, he'd be a BASIC Stamp user. Of course, he'd rewire it for 220 volts and overclock the PIC/SX to run at 10 GigaHertz so he could point at it proudly and grunt like a pig. (That's how I show off my Stamp projects, don't you?) Tim and his famous TV alter-ego both love tools — but then, don't we all? Tools are good. They help us build and create things. They're even better when they're free. And that's what we're going to chat about this month: a couple of freebie tools from Parallax. One is new, the other isn't, but has some really neat surprises.

For LCD lovers like me — it just has. About the only thing tedious when using character LCDs is designing custom characters and adding the data to a PBASIC program. Until recently, I would do like you and create my characters on paper. Ugh! Too tedious.

Enter the **LCD Character Creator**. This nifty little program (okay, I wrote it, but I still think it's nifty) lets you design and save custom LCD characters and save the definitions to use later. It supports 5x7 and 5x10 character designs and even includes the standard character set (from the Hitachi HD44780A00 ROM) so you have a starting point. The on-screen preview graphic lets you see what your custom character will look like in a display next to other characters.

Essentially, this is a little paint program for LCD characters. Left-clicking on a pixel will toggle it on or off. There's also clear, fill, invert, mirror, and flip commands. To make it easy to incorporate the new character into a PBASIC program, there's a text line at the bottom of the screen that can be copied right into your PBASIC source (this cool idea comes from Stamp user Steven M).

While the program is very easy to use, it comes with online help (Windows® HTML Help format) that explains all the menu items, includes a connection schematic (Figure 2 is right out of the help file), and demo programs for the BS2, BS2e, BS2sx, and BS2p. It'll even point your browser to the Parallax web site.

Cool Digits

While playing one day, I got the idea that I would create a custom set of digits for my LCD projects; you know, something that looked a little more sci-fi or computer-like. Creating the digits was no problem with my new program. But then — oops — I have 10 digits and only eight custom characters in an LCD.

After scratching my head for a few minutes I remembered a trick that Scott Edwards taught me. If you change the definition of a custom character that is being displayed, the LCD will change along with it. So for this project, I changed my thinking from eight custom characters to eight spots on the LCD that I could update at any time.

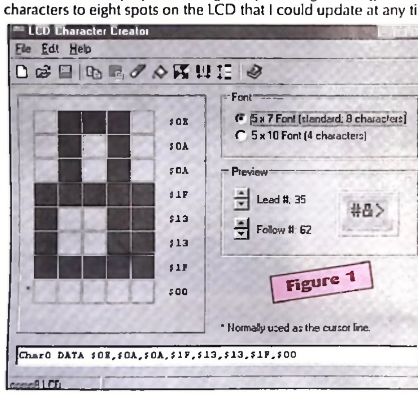


Figure 1

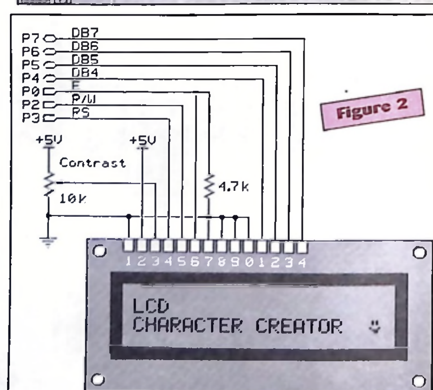


Figure 2

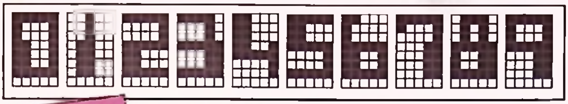


Figure 3

All I have to do is download new information to my assigned position.

Okay, let's do it. Take a look at Listing 1. This is a simple program — short and sweet. Its purpose is to display a running counter with my cool new digits. I'll use a Word variable to count from 0 to 999 and display it as 0.0 to 99.9 by inserting a decimal point between digits.

The EEPROM Data section contains the definitions for the new characters that were created with the LCD Character Creator program (you can download the files with the source code for this article). One note: The LCD Character Creator always names the data line "Char0." After pasting each line into the source file, it was renamed. The name is used as a pointer to the start of the character. We need to know the location of each character in the EEPROM so we can download it when needed to the LCD.

The LCD is initialized to operate in two-line mode. I used a 2x16 display for my experiment. I mention the width because it affects the placement of the right-justified numbers. Since we want to display three digits, we'll use custom character slots zero, one, and two. Custom character zero will display tenths, digit one will display ones, and digit two will display tens. Initialization is finished by downloading "new" zeros to digits zero and one, and a space to digit two.

Jump down to the **Update_CC**. This is the code that takes care of downloading an image map to the LCD. When we enter this routine, we pass the custom character to update in **cNum** and the beginning EEPROM address of our new character data in **addr**.

Since we've initialized the LCD to use two lines, we're forced to use the (standard) 5x7 character font which means eight bytes per character (the value of the **CLines** constant). The first line of **Update_CC** uses **LCDCMD** to point into the LCD's CGRAM (Character Generator RAM) based on the character we want to update and the number of bytes required for a definition. A **FOR-NEXT** loop grabs the new character from EEPROM with **READ**, then sends it to the LCD with **LCDOUT**. Simple and fast — which is exactly what we need since we're going to change characters on the fly.

Back in the main body of the program, we spit out a label and put our characters onscreen where we want them. Remember that digit zero is tenths, so it will be right-most in the display.

The routine called **Show_Counter** is the heart of the program. The outer loop counts from zero to 999. The inner loop scans the value of **counter** using the **DIG** operator. This conveniently returns the digit value of the position scanned. It's a simple matter of using this value to point into our table of definitions for the map of that digit.

The only exception is when the tens digit is zero — we'd rather have a leading space than a leading zero. The code checks to see if the scanned digit is the tens position (character two) and its value is zero. When this is the case we download a custom space (all zeros). It's easier to re-define a custom space than to use the standard ASCII space character (#32). If we did this, we'd actually have more code to write. Eight bytes of EE space for a definition is an easy trade.

So that's it. When the program is run, we'll see a counter with cool, high-

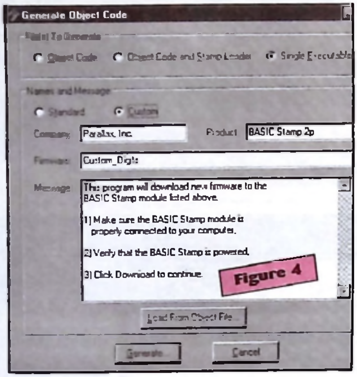


Figure 4

tech looking digits (Figure 3).

Extending this idea, you could — with a bit of creativity — use it to build larger graphics. On a 2x16 display, you could assign four characters to a 2x2 region. By downloading all four characters at once, you change the entire region, giving you quasi-graphic capabilities. It's certainly not as nice as one of the SEETRON graphical LCDs (you have character and line breaks), but it might get you by in a pinch.

An Updated Stamp Compiler

The latest release of the BASIC Stamp compiler is version 1.2. On the surface, this is a maintenance release, but under the hood ... there's a couple of really neat new features.

The fixes include the **DEBUG** window problem that has been irritating WinNT users. I know they'll be happy to read that. The program also does a better job of identifying the attached Stamp and will even suggest the proper $Stamp directive. You can't download without a $Stamp directive now and a new menu and toolbar icons make it easy to insert and change.

For those of you that don't like looking for help in another document or in a book, there's a syntax help file. If you're having trouble with a keyword, highlight it and then press F1. Presto — you're in the help file and on the correct page. If you've misspelled the word, you're taken to an index page where you'll find the correct spelling (**PULSOUT** is very frequently misspelled **PUSLEOUT**). So the fixes and minor updates are nice, but let's talk about the really cool stuff ...

One of the longest running complaints about the BS2 compiler is the lack of **BSAVE**. For those of you who never programmed the BS1, **BSAVE** caused the compiler to generate an object file that was an image map of the Stamp EEPROM. This file could be downloaded to the Stamp through a small utility. What this allowed was the ability to update a Stamp 1 project without divulging source code.

The new Stamp compiler generates object code for any of the BS2 modules and it goes way beyond what the original **BSAVE** did. Figure 4 shows the dialog that results in clicking **File > Generate Object Code**. You'll see that there are three selections: Object Code, Object Code and Stamp Loader, and Single Executable.

The Object Code selection does just that, but the BS2 object file format goes beyond a simple EEPROM map. It also contains string information that is displayed in the Stamp Loader. By selecting Custom in the Names & Messages area, we're able to customize the data displayed in the Stamp Loader.

The second selection, Object Code and Stamp Loader, is what you'll want to do the first time you run this process so that StampLoader.EXE is created. This program will load any BS2 object file and download it to a connected Stamp. By doing this, you can send StampLoader.EXE and several object files (perhaps variants on the same program) to a customer. StampLoader lets you select an object file and then downloads it at your command.

The final selection — Single Executable — is really exciting. By making this selection, we can generate a small Windows program that will update a customer's Stamp-based project — and all the customer has to do is connect the project to a PC with a serial cable and run the program. This is a real winner for consultants. The look of the executable is customized by our settings in the Generate Object Code dialog (at the time of this writing I was working with a Beta version of the software — the final release will include even more customization).

The other major improvement to the Stamp editor is completely under the hood — you can't see it. The new compiler has a command-line interface

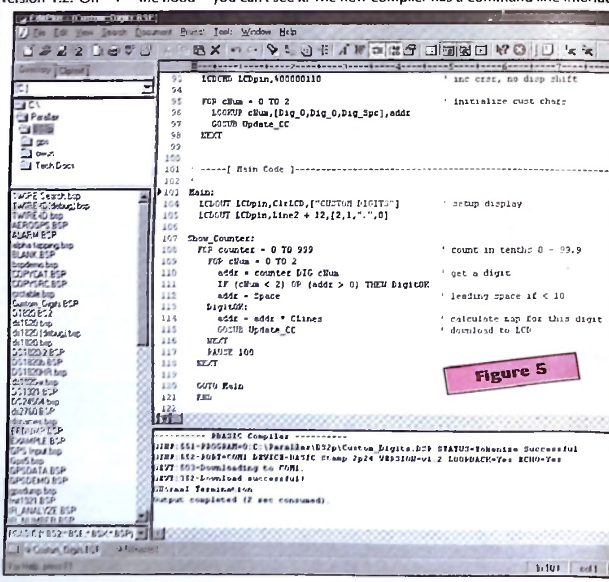


Figure 5

that allows it to be controlled by other programs. What does this mean? For starters, it means that if your favorite programming editor can launch a program with command line parameters, you can now use it to do Stamp development. You're no longer forced to write your Stamp code in the Stamp editor (but you do need to have the editor installed).

My favorite programming editor is EditPlus 2 (www.editplus.com). It's a $30.00 shareware program and consistently gets rave reviews. I like it because it has user-definable syntax highlighting and it does a great job with HTML files with its built-in browser. And since it was designed for programmers, EditPlus can launch other executables with command line parameters. It can even do keyword look-ups in your executable's help file.

Take a look at Figure 5. This is a screen shot of EditPlus after compiling and downloading the LCD program we just wrote. On the left edge is a file selection box, the main pane displays our syntax-highlighted source code, and the bottom pane shows the (successful) output from the Stamp compiler.

My purpose here is not to teach you EditPlus, but to show how to connect your favorite programming editor to the Stamp compiler. It's important that the command line switches are correct. For EditPlus, I used this argument string:

/download /noprompts "$(FilePath)"

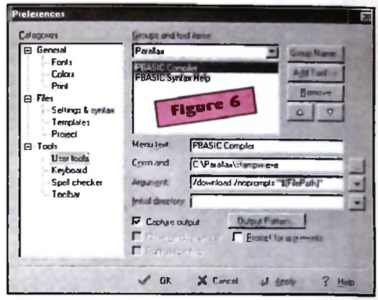


Figure 6

The first switch causes the PBASIC source file to be compiled and downloaded. If this process is not successful, you'll be alerted with an appropriate message. The second switch turns off normal message boxes — except **DEBUG**. I like this feature since I can still run programs that use **DEBUG** output from EditPlus. Of course, I can't switch between multiple **DEBUG** windows, but that's never been an issue for me, so I'm not concerned.

```
' Listing 1
' Nuts & Volts, September 2001

' -----[ Title ]-----------------------------------------------------------
'
' File...... Custom_Digits.BSP
' Purpose... Advanced LCD Demo - custom numeric font(s)
' Author.... Jon Williams
' E-mail.... jonwms@aol.com
' Started...
' Updated...

' { $STAMP BS2p }


' -----[ Program Description ]---------------------------------------------
'
' This program demonstrates character definition replacement in order to
' create a custom font for numbers.  This program uses three of the eight
' custom (CGRAM) character slots to display the tens, ones and tenths value
' of a counter.
'
' The program analyzes the counter and updates the screen by downloading
' the appropriate character map for each digit.
'
' To run this program on the BS2p Demo Board, connect the LCD and
' install Jumper X3. Adjust contrast pot for best display.
'
' Refer to the Hitachi HD44780 documentation for details on LCD control.


' -----[ Revision History ]------------------------------------------------
'


' -----[ I/O Definitions ]-------------------------------------------------
'
LCDpin          CON     0                       ' connect LCD to OutL


' -----[ Constants ]-------------------------------------------------------
'
NoCmd           CON     $00                     ' No command in LCDOUT
ClrLCD    CON   $01                             ' clear the LCD
CrsrHm    CON   $02                             ' move cursor to home position
CrsrLf    CON   $10                             ' move cursor left
CrsrRt    CON   $14                             ' move cursor right
DispLf    CON   $18                             ' shift displayed chars left
DispRt    CON   $1C                             ' shift displayed chars right
DDRam           CON     $80                     ' Display Data RAM control
CGRam           CON     $40                     ' Custom character RAM
Line1           CON     $80                     ' DDRAM address of line 1
Line2           CON     $C0                     ' DDRAM address of line 2

CLines          CON     8                       ' lines per character
Space           CON     10


' -----[ Variables ]-------------------------------------------------------
'
char            VAR     Byte                    ' character sent to LCD
addr            VAR     Byte                    ' EE starting address of map
cNum            VAR     Nib                     ' character number
idx             VAR     Nib                     ' loop counter

counter         VAR     Word


' -----[ EEPROM Data ]-----------------------------------------------------
'
' character definitions - digits 0 - 9 and space
'
Dig_0           DATA    $1F,$11,$11,$19,$19,$19,$1F,$00
Dig_1           DATA    $04,$04,$04,$0C,$0C,$0C,$0C,$00
Dig_2           DATA    $1F,$01,$01,$1F,$18,$18,$1F,$00
Dig_3           DATA    $1E,$02,$02,$1F,$03,$03,$1F,$00
Dig_4           DATA    $18,$18,$18,$19,$1F,$01,$01,$00
Dig_5           DATA    $1F,$18,$18,$1F,$01,$01,$1F,$00
Dig_6           DATA    $18,$10,$10,$1F,$19,$19,$1F,$00
Dig_7           DATA    $1F,$11,$01,$03,$03,$03,$03,$00
Dig_8           DATA    $0E,$0A,$0A,$1F,$13,$13,$1F,$00
Dig_9           DATA    $1F,$11,$11,$1F,$03,$03,$03,$00
Dig_Spc         DATA    $00,$00,$00,$00,$00,$00,$00,$00


' -----[ Initialization ]--------------------------------------------------
'
Initialize:
  PAUSE 500                                     ' let the LCD settle
  LCDCMD LCDpin,%00110000 : PAUSE 5             ' 8-bit mode
  LCDCMD LCDpin,%00110000 : PAUSE 0
  LCDCMD LCDpin,%00110000 : PAUSE 0
  LCDCMD LCDpin,%00100000 : PAUSE 0             ' 4-bit mode
  LCDCMD LCDpin,%00101000 : PAUSE 0             ' 2-line mode
  LCDCMD LCDpin,%00001100 : PAUSE 0             ' no crsr, no blink
  LCDCMD LCDpin,%00000110                       ' inc crsr, no disp
shift

  FOR cNum = 0 TO 2                             ' initialize cust chars
    LOOKUP cNum,[Dig_0,Dig_0,Dig_Spc],addr
    GOSUB Update_CC
  NEXT


' -----[ Main Code ]-------------------------------------------------------
'
Main:
  LCDOUT LCDpin,ClrLCD,["CUSTOM DIGITS"]  ' setup display
  LCDOUT LCDpin,Line2 + 12,[2,1,".",0]

Show_Counter:
  FOR counter = 0 TO 999                        ' count in tenths 0 - 99.9
    FOR cNum = 0 TO 2
      addr = counter DIG cNum                   ' get a digit
      IF (cNum < 2) OR (addr > 0) THEN DigitOK
      addr = Space                              ' leading space if < 10
    DigitOK:
      addr = addr * CLines                      ' calculate map for this digit
      GOSUB Update_CC                           ' download to LCD
    NEXT
    PAUSE 100
  NEXT

  GOTO Main
  END


' -----[ Subroutines ]-----------------------------------------------------
'
Update_CC:                                      ' update custom character
  LCDCMD LCDpin,(CGRam + (cNum * CLines))' point to start of character map
  FOR idx = 0 TO (CLines - 1)
    READ (addr + idx),char                      ' get data for character line
    LCDOUT LCDpin,NoCmd,[char]                  ' write to LCD CGRAM
  NEXT
  RETURN
```

The "$(FilePath)" parameter tells EditPlus to send the filename and complete path to the Stamp compiler. The reason it's quoted is that I use long filenames with spaces. Spaces in the filename will create a problem for the Stamp editor if you don't use the quotes. Better to be safe than sorry.

The Stamp compiler requires command-line controlled output to be directed to a standard output. With EditPlus (and other editors), this output can be captured so no file was specified. If your favorite editor doesn't capture this data, be sure to redirect the output to a text file. You can do that by adding this bit of text to your argument string:

```
> stampout.txt
```

If things don't proceed as you expect, you can open this file and find out why.

Well, that's about all we have time for this month. For those of you interested in EditPlus, I've included the PBASIC syntax definition in this month's project files. Be sure to check the Parallax web site for the availability of LCD Character Creator and the new Stamp compiler.

Couldn't Get Back Issues?

From time-to-time, I'll get a question via email that causes me to reference a past issue of *Nuts & Volts*. Between Scott Edwards, Lon Glazner, and myself, we've written over 75 Stamp Applications articles. That's a lot of Stamp stuff. Unfortunately, back issues are not always available and occasionally left us scrambling to dig out old files.

Not any more. Ken Gracey of Parallax worked with *Nuts & Volts* to compile Stamp Applications columns 1 through 75 into a two-volume book set. Between the two books, there are nearly 1,000 pages of BASIC Stamp programming tips and projects. All of the source code and related files are included on a CD.

You can order the books from *Nuts & Volts* or Parallax. Better do it quick though — these babies will go fast.

Resources:

Jon Williams
3718 Valley View Lane, #3040
Irving, TX 75062
(972) 659-9090
jonwms@aol.com

Parallax
599 Menlo Drive, Suite 100
Rocklin, CA 95756
(888) 512-1024
www.parallaxinc.com

Until next time, Happy Stamping. **NV**

Circle #52 on the Reader Service Card.

Gravity, Inertia, and the Electromagnetic Spectrum — Part 1

by Richard Panosh

Far from the planet, the saucer-shaped earth cruiser approached Altair Four at a velocity close to the speed of light. The two pitted moons of Altair Four were visible as the cruiser spiraled toward the planet. At an altitude of nearly 80 miles above the planet, the navigational computer instructed the craft to decelerate and prepare to plunge into the dense atmosphere of the planet.

In the year 2200, re-entry was not as critical as it had been for earlier rocket-propelled space ships. Early rocket ships had been restricted to a very narrow and precise re-entry cone, otherwise the ship would either dip into the dense atmosphere and burn up, or it would enter at too shallow of an angle and ricochet back out into space.

In a fraction of a second, the spacecraft reduced its velocity for safe entry into the protective atmosphere of the planet. Inside, the occupants were unaware of the change in acceleration. On their forward monitor they saw half of the planet surface below slowly rotating in darkness and the other half was softly illuminated by a green sky that revealed the pink desert surface far below.

The cruiser approached the surface in a long sloping trajectory, crossing over smooth desert plains punctuated with an occasional deep canyon and in some places surrounded by rugged mountains. Aboard the cruiser, sensitive instruments were actively probing the planet with the full array of invasive spread-spectrum electromagnetic waves and also passive detectors were actively recording every minute detail.

Far from the planet, the saucer-shaped earth cruiser approached Altair Four at a velocity close to the speed of light.

Once sentient life forms were detected, the navigational computer immediately made a course correction and the cruiser veered off at a sharp right angle and began to flutter down to the surface of the planet like a leaf in a soft summer breeze.

Is this science fiction or the future magic of technology? In this case, it's the opening scene of the 1956 science fiction movie "Forbidden Planet," but science fiction has a way of becoming reality. Perhaps it is the very nature of these dreams that are indeed projected into reality, because the dream must precede the development.

Today we accept aircraft that travel faster than the speed of sound, vertical take-off aircraft, satellites, space exploration, electronic communications, and the ever-shrinking integrated circuits that make it all possible. Not too long ago, none of these things existed.

The study of physics is an accumulation of man's knowledge dating before Aristole (384-322 BC). Galileo Galilei (1554-1642) was the first to develop the relationship of mass and acceleration by experimenting with balls that he rolled down inclined planes. Sir Isaac Newton (1642-1727) and many others saw that these ideas could be applied to the moon and planets. In 1666 on a trip to the country, Newton discovered the force of gravity while watching an apple fall from a tree. He realized that this force orchestrated the heavenly bodies in their orbits. He described gravity as a force that acted through a distance, such that the magnitude of the force is proportional to the inverse square of the distance. This is similar to the force developed between charged particles.

Newtonian mechanics was applied to the observation of planetary motion and able to predict additional planets in our solar system. As late as 1930, the ninth planet of our solar system, Pluto, was discovered from perturbations of Neptune's orbit. In 1969, Neil Armstrong became the first man to walk on the moon. His '... giant leap for mankind' was preceded by a series of unmanned Lunar Orbiters. The job of the unmanned Lunar Orbiters were to plot gravitational anomalies at the moon's surface from orbital perturbations. Computers could then locate these "Mascons" so that the manned orbitors that would eventually follow could be given a rocket boost of power to maintain a correct orbit.

In 1915, Albert Einstein (1879-1955) published his *General Theory of Relativity* concerning space, time, and gravity. Einstein's theory describes gravity not as a force, but as a property of curved space. Matter is visualized as producing a curve in the fabric of space much as a ball on a stretched rubber membrane will form a slight depression in the membrane. The depth of the depression is dependent upon the size or mass of the ball.

You experience the effect of warped space whenever you push your lawnmower adjacent to a depression in the lawn. The outer set of wheels travel a different distance than the inner wheels and the result is to curve the path of the mower.

While Newtonian mechanics has been quite successful in describing gravitational phenomena, it failed to explain perturbations in the orbit of the planet closest to the Sun, Mercury. It was found that Newtonian mechanics was reasonably accurate in weak fields and at low velocities, but deficiencies became apparent when the gravitational field became larger.

Einstein's theory successfully explained the perturbations in Mercury's orbit and also predicted the bending of light and the shift of light waves to the red/blue wavelength due to the effects of gravity. Newton's theory failed to predict these effects. In addition, Einstein's theory also predicted changes in the unit of length and the unit of time at high velocities and added the phenomenon of gravitational waves. The first two have been verified to a remarkable degree by experiments and the effect of gravitational waves is implied by astronomical observation.

Two experiments are currently underway to improve the sensitivity of gravitation wave detectors. The US effort is called LIGO (Laser Interferometer Gravitational-Wave Observatory) and consist of two sites for coincidence experiments.

Each site has already been constructed to house a 4 km long interferometer at Hanford, WA and the second is located 3,000 km away in Livingston, VA. The first sensitive searches of these instruments are due to begin in 2002. Another experimental set-up is the European instrument known as VIRGO. Einstein's theory predicts only two modes of polarization for the waves and the propagation velocity should be equal to that of light in the same region of space.

The strong field gravitational interaction was further tested in 1974 with the discovery of the binary pulsar PSR 1913+16 (a pair of very dense Neutron stars). Since then, other binary pulsars have furnished tests of the theory. Just as Newtonian mechanics began to break down at moderate gravitational field strength, so Einstein's theory has been pressed for flaws at ever increasing field intensities.

Astronomers have recognized five stellar configurations that exhibit relativistic effects: white dwarfs, neutron stars, black holes, supermassive stars, and relativistic star clusters. While Einstein's theory has been the most consistent with observation, it does not fully describe the situation. This coupled with the desire to unify gravity with quantum mechanics into a single grand unified theory of all forces requires the theory of Quantum Gravity.

Another theoretical approach that combines quantum mechanical concepts and classical electrodynamics, sometimes referred to as SED (Stochastic Electro-Dynamics), has had a long history of yielding results consistent with QED (Quantum Electro-Dynamics).

The basic theory couples Newtonian mechanics with James Maxwell's (1831-1879) electromagnetic equations. The classical boundary conditions for Maxwell's equations are altered to include a random radiation, referred to as the ZPF (Zero Point Field). This ZPF is basically the texture of space and often described as the boiling, seething quantum foam at the smallest scale of distances of about 10E-33 cm (smaller than the diameter of an atom by 10E21) and is called Planck's length.

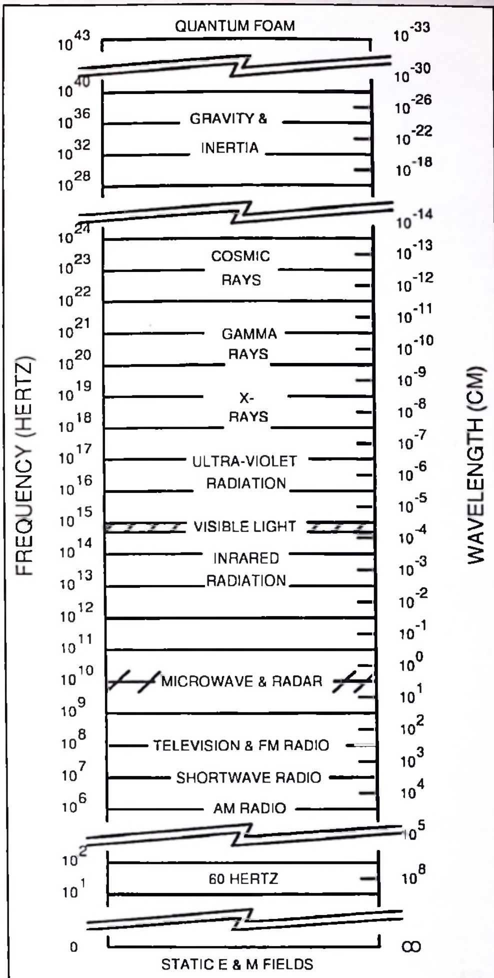


Figure 1. Complete Electromagnetic Spectrum

SED is a useful tool that is both straightforward and intuitively clear. It has been used to explain the following effects: (1) the Casimir effect in which a force is developed between closely-spaced parallel plates due to the ZPF in a resonate cavity, (2) the Lamb shift in which small perturbations have been detected in the electron orbit of hydrogen caused by the ZPF, (3) the Van der Waals forces between macroscopic objects as a result of the ZPF, (4) the spontaneous emission of photons appears to be stimulated by the ZPF, and (5) quantum noise sets a lower limit to detectability of electromagnetic signals and measurements due to the ZPF.

In 1989, H. Puthoff published a paper "Gravity as a zero-point-fluctuation force" employing SED to expand on an earlier theory proposed by Andrei Sakharov (1921-1989), the father of the Soviet H-Bomb. The theory describes gravity as the force developed between small Planck length dipoles (partons) that make up all matter and interact with the electric field of the ZPF at the shortest wavelengths. The paper develops a Newtonian-style solution with no adjustable parameters.

In this analysis, ordinary matter is defined as a collection of charged point dipoles (partons) that respond as small oscillators that are characterized by a constant radiation damping and a characteristic frequency bathed in ultra short wavelength (Planckian) ZPF radiation from all other matter.

This approach is analogous to the 1900 work of Max Planck (1858-1947) in describing black body radiation in terms of matter that consists of bound oscillators that interact with electromagnetic radiation. Planck's work led to the development of quantum mechanics and further development in this direction was abandoned.

Basically, this theory defines gravity as a force due to the electromagnetic interactions, not as the property of a warped space. In a sense, the warp of space becomes the gradient of the Planck wavelength electromagnetic field.

The interaction of the dipoles and electric field are identical to the forces developed in a dielectric placed between the plates of a capacitor. Part 2 will discuss this aspect in more detail and describe several experiments that were performed.

The SED approach gives a simple picture of gravitational forces and attributes the lack of shielding to the fact that matter is particularly dilute and completely bathed in a sea of very short wavelength random electromagnetic energy (the ZPF). This assumption is valid since Planck's length is on the order of 10E-33 cm and atoms are on the order of 10E-12 cm (21 orders of magnitude larger). To be effective, an electromagnetic shield has to be dense enough to attenuate the field distribution and thereby produce shielding.

In 1994, H. Puthoff was co-author with B. Haisch and A. Rueda on the paper "Inertia as a zero-point-field Lorentz force." Using the SED technique, they successfully described inertia as a retarding force produced by the interaction of the electric field of the parton as it is dragged through the magnetic field of the ZPF. Both effects — gravity and inertia — are seen to arise from the very high frequency electromagnetic components of the ZPF, which also explains why it has been so difficult to recognize the connection.

Maxwell developed the equations that describe the propagation of light and all electromagnetic waves in the 1860's. Gugliemo Marconi (1874-1937) and Nikola Tesla (1856-1943) are given credit for the invention of radio around 1895 and Marconi made his famous trans-Atlantic transmission in 1901.

The complete electromagnetic spectrum is illustrated in Figure 1 with the shortest Planck length waves responsible for the effects of gravity and inertia included. The bottom end of the electromagnetic spectrum is, of course, the ultra long wavelengths. The wavelength for a 60 Hz wave is about 3,000 mile long. Currently, much development is being directed in the 10E-3 cm wavelength band (0.3-10 THz) because it offers high bandwidths, improved spatial resolution, and has applications to molecular spectroscopy.

Imagine the bandwidth available at these short Planck wavelengths. One can only wonder when the FCC will also discover the upper electromagnetic frequencies and try to auction off the gravitational band?

The somewhat oversimplifications of an ideal oscillator interacting with the ZPF, as well as the mathematical complexity of both theories, were obvious sources of skepticism. Recently, an alternate derivation of inertia was developed directly from Maxwell's equation. In addition, a relativistic form of the inertia equation has been derived that circumvents the skepticism and provides deeper insight. While both special relativity and general relativity involve inertia, neither gives any insight into its origins.

Prior to this theory, inertia has only been described as a property of matter. In addition, the introduction of the ZPF is consistent with Ernst Mach's (1838-1916) principle. Mach made the philosophical statement that all motion is relative and any motion is devoid of meaning without the surrounding matter. Other matter is required to establish a frame of reference — "the fixed star" becomes the ZPF.

The gravitational ZPF theory has met with more resistance than the inertia theory. While presenting some insight into a mechanism for the force of gravity and the lack of shielding, it only develops a Newtonian form of equation as opposed to Einstein's space-time curvature that is rich in predictions of lensing, black holes, etc. However, the inertial theory lends much support to the gravitation theory through the intimate definition and interpretation of mass as an interaction with the ZPF.

Obviously, further development is required, but the door stands slightly agar to the possibility that both gravity and inertia can be manipulated since both properties arise in electrodynamics. This would fulfill Einstein's dream of an 'electro-gravity' that would complete the work started by Maxwell. It would also incorporate the concept of controlling inertia inherent with gravitational propulsion that would make possible nearly instantaneous acceleration, right angle turns, and silent hovering to bring us full circle to our science fiction introduction.

Sorry, but there is no warp drive. Guess we will all have to concentrate on that dream, both harder and longer.

Part 2 will deal with some experimental aspects, plus references and web sites for additional information. **NV**

TECH FORUM

This is a READER TO READER Column. All questions AND answers will be provided by Nuts & Volts readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and NO GUARANTEES WHATSOEVER are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

Don't forget to check out the new online electronics forums at the *Nuts & Volts* website. There are currently boards for discussing Robotics, Microcontrollers, Radio, Computers, CNC, and a General forum for discussing any electronic topic at all. We'll even add new dedicated boards for hot topics. Just let us know!

Want to get a jump on things before the magazine arrives? The Tech Forum questions are posted on our website on or before the first of each month. Unanswered questions from recent issues are there also.

Send all material to **Nuts & Volts Magazine**, 430 Princeland Court, Corona, CA 92879, OR fax to (909) 371-3052, OR E-Mail to **forum@nutsvolts.com**

QUESTIONS

I'm looking for schematics on a Toshiba PCX1100 cable modem or any source of information regarding the details of its operation, motherboard layout, etc. Apparently, these modems only work on a 10baseT ethernet. I want to modify the modem so it will work on both 10baseT and 100baseT.

Any help in leading me in the right direction would be fantastic.

9011 **Christian**
via Internet

I have an Allen Electric & Equipment Co. (formerly of Kalamazoo, MI), model E313 growler (motor armature tester) that I would first like to rewire, and then learn how to use it!

I need a schematic and operating instructions.

9012 **Peter Stratigos**
via Internet

I have an old, but still well-used (1977) Heathkit Digital Floor Clock/Chime (GC-1195). It had 24 small incandescent display lamps driven by 24 PNP grounded emitter transistors that provided a 3.5" high, four- digit display using 24, 1.5" x 0.25" rectangular lens covers over each segment lamp.

The now very rare/discontinued lamps were replaced with 24 ultra bright (3000 MCD) yellow 1.3/4 LEDs with the original dimming function retained. The main clock 40-pin LSI chip was a non-multiplex type of chip that provided 24 actual leads — one to each of the four number segments and colon that has just failed.

There are now only about five or six of these, now very costly, large scale integrated non-mux clock chips left in the world!

I would like to replace the small main clock board with an all new current clock IC chip board (keeping the current display board), but found they are all the multiplex type and while the display (now LED) could be cut up and re-wired to separate/isolate the common ground leads into four groups, there would be additional issues with the seven control segment leads that also multiple to the clock chime board control inputs and the 1/4 hour chiming outputs

Is there an easy/practical way to convert a new clock board's seven-segment LED output and multiplexing leads into 24 non-mux leads (i.e., 24 optical isolators with capacitors to block the on/off mux sequencing of the segments or op-amp comparators across the new display segment LEDs, etc.)?

9013 **Tom Murtaugh**
via Internet

ANSWERS

ANSWER TO #8014 - AUG. 2001

I found a web page that told of an American university student who invented a new way of sampling TV images to allow recombining them so as to get 3DTV. He applied for a provisional patent, was written up in some magazines, and has his prototype unit in the basement of his university.

I do not remember anything but these general facts. Can anyone help?

Michael Starks has an extensive background in science with five years of graduate study at UC Berkeley. He began exhaustive research on the patent and technical literature of stereoscopy (true 3D imaging) in 1973.

In 1989, he founded 3DTV Corp. and began producing and selling the world's first commercial home 3DTV system with 3D movies on videotape.

The above has been excerpted from **http://www.3dmagic.com/personal.html**.

There is also extensive material on 3D films, TV, and related products on that site.

Barry Cole
Camas, WA

ANSWER TO #8015 - AUG. 2001

About 10 years ago, I remember there being a short craze on water-powered watches. I'm not sure what principle these worked on, but I would be interested in using it for my own projects.

Any information about this technology would be much appreciated.

I'm not familiar with the craze of water-powered watches, but the technology behind such a thing comes from the fact that even tap water has charged particles known in the industry as ions.

Without getting into physics 101 and keeping it short, each atom in the universe contains either positive or negative values for these ions and thus they can be tapped for this electrical value or potential.

In the chrome factory where I once worked, we had to de-ionize all of the water that ended up in the plating tanks. We had a special de-ionizing plant that would take the charge out of the water through osmosis, chemical action, and filtration because if there was any excess potential leftover in the water, or if the water had the potential to conduct easily because of impurities, it would interfere like a buffer or charge between the metals, the acids, and the generating source. It would either displace some of the metal being deposited or simply deposit those impurities in place of some of the plating materials.

Because most LCD watches consume less than the "static potential" that resides in your body at the present moment, I would assume that a drop of water, especially one that is dirty with some minerals or two, would easily power one of the LCD watches for days, if not weeks.

Some of the newer watches will run for three or more years on a single tiny battery making its draw somewhere in the "Pico" amp range, while ionized water can easily hold that amount of charge.

I would say two tiny electrodes placed close together in a tiny vial (or two) should do the trick. I think your physical manufacturing requirements will be your hardest

ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of $25.00 will be sent if your answer is printed. Be sure to include your mailing address if responding by E-Mail or we can not send payment.
- Your name, city, and state, will be printed in the magazine, unless you notify us otherwise. If you want your email address printed also, indicate to that effect.
- The question number and a short summary of the original question will be printed above the answer.
- Unanswered questions from a past issue may still be responded to.
- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

QUESTION INFO

TO BE CONSIDERED

All questions should relate to one or more of the following:
1) Circuit Design **3)** Problem Solving
2) Electronic Theory **4)** Other Similar Topics

INFORMATION/RESTRICTIONS

- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions may be subject to editing.

HELPFUL HINTS

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address, Phone Number, and email. Only your name, city, and state will be published with the question, but we may need to contact you.

ANSWERS TO #8011 - AUG. 2001

My friend bought an older motel. The front desk switchboard for the room's telephones is an aging model with little or no tech support.

Is there a way we can use a desk phone, small laptop computer, and some kind of interface box as a substitute for the old console to control the six phone lines that enter the motel?

The software needs to switch calls between rooms and scan for an open line for outgoing calls.

#1 Having installed and maintained PBXs (Private Branch eXchange) for 20 years, I must tell you it can't be done.

If the PBX console is electronic, its data format for communicating with the PBX is of a proprietary format. In other words, the engineer that designed the system, made up his own code to transmit between console and system. These codes are not compatible with computers which use ASCII as the transmitted data.

Another thing to consider, if the PBX is capable of communicating with a laptop, it would have already been using one.

Dennis Hewett
Frontenac, KS

#2 A company called CMP (Call Management Products) sells something like this.

They can be reached at **www.callmgmtprod.com** or **303-465-0651**.

Geoff Probert
via Internet

trick if you plan to make it into a watch.

A "stick up clock" or cheap watch would be a good starting point because some of these watches can be run for several seconds or minutes with a dead battery in place just by rubbing the case or glass cover, or even warming it when it's cold with your hands. The only draw back that I can foresee is the fact that you may have to stack multiple water cells similar to multiple batteries in order to gain the potential voltage or current depending on your brand of watch and its requirements.

Chris
Bieber, CA

ANSWER TO #60110 - JUNE 2001

I'm trying to find a circuit that will replace a voltage regulator assembly from a Homelite EHE 4400 AC generator. From what I see, it's a revolving field type with an exciter coil in the stator.

The rotor and stator are both two pole (3,600 RPM). Their slip ring/brush assembly connecting the rotor to the regulator is, I assume to deliver DC excitation current to the rotor. When I run the engine and connect DC from my power supply to the rotor, the generator works fine. I rang out all windings and none of the resistance values seem out of the ordinary. Any information on a replacement part or a circuit diagram would be greatly appreciated!

If your AC alternator produces voltage when the field is not energized, then it can be self-starting by rectifying the AC, otherwise you will need a battery to get it started. The regulator should include a transformer and full-wave rectifier, to keep DC out of the alternator stator and minimize the filtering.

I have built a regulator for an automotive DC generator, the same circuit should work here, although the current and voltage requirements may be higher. It may not be necessary to filter the rectified AC, but a ripple in the field current will distort the AC waveform. Contact me at **russlk@att.net** if you want a copy of my circuit.

Russell Kincaid
Milford, NH

ANSWERS TO #8016 - AUG. 2001

Is there any way I can power a device already connected to the phone line (providing an audio signal), but also drawing power (6 VDC-60uA) directly from the phone line? A diagram would be greatly appreciated.

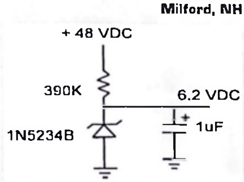
#1 You need to give more detail than "device." The more current-consuming "devices" you connect, the more the "busy voltage" drops. Idle telephone lines read around 48 volts, and busy lines will read anywhere from 5 to 12 volts, depending on your distance from the central office. If you connect too many current-consuming "devices" on a line, it may not disconnect after you use it when these devices are first connected.

Dennis Hewett
Frontenac, KS

#2 The nominal voltage on the telephone line is 48 VDC, so you just need a resistor and zener diode. The current is small enough that the telephone company should not get concerned by the load. The 1uF capacitor is to filter any ring voltage that may otherwise get through.

Parts are available from RadioShack.com: Zener diode = 900-3091, 1uF cap = 900-2170, resistor = 900- 0127.

Russell Kincaid
Milford, NH



ANSWER TO #6014 - JUNE 2001

I'm trying to find any information relating to electro magnetic or magnetic power.

I have searched the libraries in California and here in Arizona, and can't seem to find anything that doesn't require a degree in nuclear science.

Can anyone refer me to any publications that can be understood by the average person?

Magnetic properties are nonlinear and therefore complex, but you can sometimes "cookbook" a solution from the manufacturer's data.

I suggest that you check out the websites of **Magnetics**, Inc. at **www.mag-inc.com** and Micrometals, **www.micrometals.com**.

Russell Kincaid
Milford, NH

ANSWER TO #8013 - AUG. 2001

What is the wiring diagram for a ceiling fan with a four-position pull chain switch (off, high, medium, low)? What would happen if the wires for the speed changes were mixed up? Would it only affect the order or would it cause damage?

I just installed a couple of weeks ago, two older ceiling fans that didn't come with any wiring diagrams. The first thing I noticed with both fans was that only two of the four wires are actually for the motor even though one of them was a single-speed fan with external speed control (light dimmer type) and the other was a four position pull chain.

In both cases, the other two wires were for the lighting circuit even though they may or may not have a light fixture installed. One black (power) and one white (neg/ground) wire power the fan motor and the others (two or three wires) are usually for the lighting. Again, in both cases, the lighting wires were smaller in size (16 or 18 gauge) and may be the following colors. Yellow, blue, brown, or red.

If you have a light socket already installed, take it apart to see if there are any exposed wires or shorts, noting the colors. If you have no light fixture installed, then remove the cover plate and again inspect the lighting wires for exposure or shorting and note the colors. There is usually a 1/4" ID hollow tube that runs completely through the center of the fan motor assembly to allow these wires to end up at the other end of the fan to power and hold the light fixture to the fan assembly. This tube is the standard size and thread type used on all American lighting and lamps fixtures found in the home.

Chris
Bieber, CA

ANSWERS TO #8017 - AUG. 2001

I do electronic board repair for a textile mill. A young man whose father used to work with me came to me with a problem.

He overloaded the stereo with speakers and as soon as the power button is pressed, it shows protect, and 24 hours later when powered up, it goes through a display. I have used the buttons to clear the memory several times with no results.

I'm no TV or stereo repair man, but this kid believes in me. Sharp says take it to a repair shop. They quote $50-$250, but this kid doesn't have that kind of money.

I wish someone would tell me how to correct this problem. I would sure like to help this kid and I would appreciate someone coming to our rescue. I've been with Nuts & Volts for about 20 years and have seen it come a long way. I'm self-taught in electronics and try hard, but I know my limits.

#1 It's likely that the power output IC(s) are blown due to the overload. This is causing the power supply to go into protect mode so as not to smoke the unit. If you remove the power ICs and the unit then powers up, replace them. If it still does not power up, then you have a power supply problem which should be easy to trace, or you should send the unit to a repair shop.

Russell Kincaid
Milford, NH

#2 Having repaired a few stereos in my time, what it sounds like — if I read you correct — by adding too many speakers to the system you have changed the impedance of the output and this can act like a heavy load or virtual short. Permanent damage may have already been done.

Resetting codes and playing around with the processor won't help if the finals are damaged or compromised.

The areas I would concentrate on are the impedance matching final resistors which your system may or may not incorporate. If you have these resistors, they will usually be a large "sand-type" resistor about one or two inches long. See if they are smoked, cracked, or they have a burnt smell. Also check to see if they have become un-soldered due to overheating.

Next, I would move along to see if you have a "final" transistor set-up such as the TO-220 or the TO-5 style and, if incorporated, test them for getting hot, see if they have become un-soldered due to overheating, check for "no current flow" because they are fried, or the usual array of transistor checks that are used in any standard circuit.

If you have this design, they will be located fairly close to the back section of the circuit board close to where the speaker wires connect to the back plate or jumpers. Check to see if there are "final" fuses installed in the same area because many manufacturers incorporate these into their design as a fail-safe system in case of a dead short. Some manufacturers replace the fuse with a circuit breaker instead of a one-time fuse.

Next, you may have the "Solid-State Module" type of stereo and again check for input VS output voltages and current. The module may be the complete type which is usually around two square inches in size, and it is always attached to a heatsink of the same size.

It also might be broken down into two or more smaller chip type amps (usually four) and so treat them the same and check each amp separately.

A set of head phones can be modified to check for pre-amp and amp damage or operation. The module or chip can be completely fried so check for overheating, running stone cold, smell, and any physical damage such as a cracked plastic housing or burnt plastic.

Other than this, you need to have good knowledge and experience in troubleshooting and audio circuits because it could be anything.

Depending on age, any one of these systems may be incorporated in your stereo and you need to determine which, if any, is your type.

Chris
Bieber, CA

#3 The protect usually indicates that there is a fault on the output. These circuits are used to detect excessive DC from the power amplifier. There is probably a relay that connects the amplifier section to the output terminals. Find the input side and check for DC. If it is above a few millivolts, then the power amplifier is probably shorted.

This type of failure can put quite a load on the power supply and affect other stages, as well. It is likely that this unit uses a hybrid power module of some kind so, it should be relatively easy to repair.

Please use care when poking around as there is a lot of energy available. Also use an isolation transformer if you have one available.

Al Sekeet
Grand Rapids, MI

Techknowledgey 2001 *Continued From Page 7*

Avanti Executives Fined, Sentenced to Prison

If you have been under the impression that theft of intellectual property always goes unpunished, consider the case of Avanti Corp. (**www.avanti-corp.com**), the IC design software vendor. Late in July, a six-year-old legal case against the company concluded with co-founder Stephen Wuu being dragged away in handcuffs to spend two years in San Quentin State Prison. Wuu, who is no longer with the company, also was slapped with $2.7 million in fines. Other Avanti executives who will be spending time in the slammer include Yuh-Zen Liao ($2.7 in fines, one year in jail), Eric Cho ($108,000 in fines, one year in jail), Eric Cheng ($27,000 in fines, 364 days in jail), and Mitch Igusa (one year in jail). In addition, former president and CEO Gerald Hsu was fined $2.7 million but, as part of a plea bargaining agreement, will avoid prison and stay on as Chairman and Chief Strategist. Avanti was also ordered to pay more than $195 million to Cadence Design Systems, Inc. (**www.cadence.com**), as restitution for Wuu's theft of Cadence's Symbad database code back in 1991.

Avanti's new president, Paul Lo, was quoted as saying that the company is "facing great challenges but also tremendous opportunities." With customers and employees running for the exits, and Avanti stock prices having dropped from a high of $27.00 in February to $5.80 as of this writing, it appears that the challenges will take up most of Mr. Lo's time.

A Dim Ray of Hope for Internet Companies

In an industry in which "dot-com" businesses have been becoming "dot-gone" in droves, there seems to be at least an upturn in the downturn. According to Challenger, Gray & Christmas, Inc., July layoffs in the Internet service industry were only 8,697, which was the lowest since last October, when only 5,677 workers lost their jobs. It was also an improvement over the 9,216 layoffs in June. Challenger (**www.challengergray.com/**) is a consulting firm that works with employers to find new employment for executive and middle management employees who are being terminated. **NV**

LITTLE AUTO TUNERS FOR LITTLE RADIOS

Gordo puts automatic antenna tuners and couplers to the sea water ground test.

by Gordon West

The front and rear of the LDG antenna coupler AT-11MP.

One of the best signals you will put out and receive on high frequency (3 MHz-30 MHz) is with a well-elevated halfwave dipole. Each side of the dipole is one-quarter wavelength long, and the overall length of the dipole is half the wavelength you are transmitting on, based on the formula: length in feet = 486 ÷ MHz. This is the overall length, end to end, with an insulator or balun in the center to separate each one-quarter wavelength section.

The halfwave dipole is probably the most economic way to get an excellent signal on the high-frequency bands; and if all you have is just one high point of attachment, you could haul up the center of the dipole and droop each end down at about a 45-degree angle which also improves transmission and reception off the ends of the dipole, too.

You may even "roll your own" feedpoint isolator by taking 10 turns of RG58A/U coax around a toilet paper cardboard center, and as long as you trim the dipole one inch at a time, you should be able to bring the SWR "dip" just about flat anywhere in the single-band operation.

You can even get 15 meters to play on a 40-meter-cut dipole. You may also get three additional lower bands of resonance on a single dipole feedline by fanning out different band half wavelengths below the lowest frequency band, such as 40 meters.

Another way to get multiple-band capabilities out of a dipole antenna system is to purchase multi-band dipoles, already rigged up with individual elements fanned down from the balun or going for a trap dipole. To see what these dipoles look like, log onto www.alphadeltacom.com and www.radioworks.com.

Jim Thompson W4THU (at the Radio Works; 757-484-0140), has a terrific free catalog available on wire antennas, plus his popular book *Frequently Asked Questions About Antenna Systems.*

Well-elevated dipoles (at least one-half wavelength above the ground) are the benchmark for measuring gain improvement from beams, as well as comparative "almost as good as a dipole" measurements from vertically loaded antennas like mobile whips and base station trap verticals.

AUTOMATIC COUPLERS HAVE THEIR PLACE

The automatic antenna coupler is a several-hundred-dollar, active, antenna-loading tuner specifically designed to take as much of your transmitter power and impress it as RF current into your antenna wire. The automatic antenna coupler is a distinct separate box than what you may find built into the high-frequency ham radio transceiver as a "built-in auto tuner." The transceiver's built-in auto tuner may be more considered an "auto trimmer," resolving elevated SWR down to a minimum for full transmit power out. Most built-in automatic antenna tuners will handle SWRs of less than 4 to 1, but seldom over 5 to 1.

This is well described in *Your Guide To HF Fun*, just released by Dave Ingram K4TWJ, Birmingham, AL, available at most ham radio stores (www.aesham.com).

The fully automatic antenna coupler is usually a remote-mounted, active electronic "box" that gets hidden away near the antenna feedpoint aboard boats, up in attics, on the roofs of motorhomes, and in the tail of airplanes. The remote-mounted automatic antenna coupler relay-clicks in variable amounts of fixed inductors and fixed capacitors to maximize output current to the desired radiating wire. Aboard boats, this wire may be insulated rigging or plastic-covered wire hoisted to the top of the sailboat or power boat mast or super-structure. In an attic, the remote-mounted auto coupler could feed a wire that runs along the main beam. In airplanes, the remote-mounted coupler feeds a tail wire to the wing tip or a trailing wire, and in motorhomes, a wire that may run around the top of the vehicle.

But for the automatic antenna coupler to perform properly, it needs a low-resistance counterpoise and ground system below the tuner. For boats, copper foil temporarily tossed overboard or permanently connected to an underwater ground plate or metallic through-hull does the job nicely. For the attic antenna, the automatic remote-mounted automatic antenna coupler may use water pipes, aluminum ducting, or chicken wire lining the inside walls as an effective ground system. Airplanes and motorhomes may use the body as a ground.

We recently tested automatic antenna couplers from both SGC, Inc. (www.sgcworld.com) and a brand new, non-remote mounted tuner from LDG Electronics (www.ldgelectronics.com). We chose to test these two lines of automatic antenna couplers because they will work with any high-frequency transceiver without data start and stop tune commands, and both companies produce several different versions of their automatic antenna couplers that will work with the new, exciting, low-power transceivers like the SGC 2020, Yaesu FT-817 (all the way down to one watt), and other high-frequency QRP transceivers from Elecraft, MFJ, Sierra, and Ten Tec.

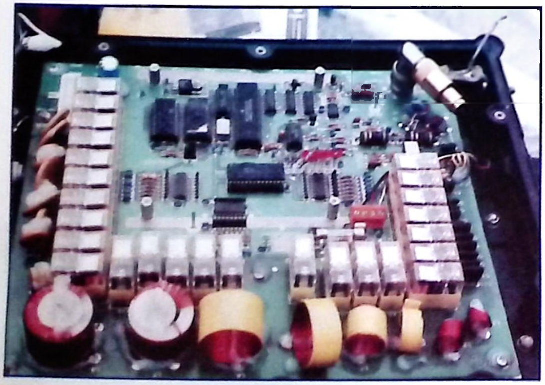
I decided to test these tuners in a common sailboat maritime mobile configuration where the mariner had insulated a mast supporting stay giving us over 65 feet of unobstructed, almost-vertical radiation. Our ground system would consist of four options — the embedded copper foil ground in the hull (not touching sea water), a second ground system made up of the boat's internal metal tanks with a very long wire run to the sea water, and our third and fourth temporary grounding systems of 3" wide, 3-mil, copper foil that we would temporarily toss over the stern end of the boat. We would use a modified Alphadelta switch to rapidly change over the different ground systems, re-tune, and then see what type of skywave reports we would obtain from other stations thousands of miles away.

The capacitive ground system made all of the tuners hunt and hunt for a proper tune lock. Neither of the two capacitive ground systems inside the hull would generate enough current in the insulated backstay to show a good, strong meter reading with our MFJ antenna current probe, nor any real brilliance on a florescent tube held next to the antenna output wire.

But when we switched over to our copper foil hanging 30 feet underwater to the muddy bottom, antenna current immediately jumped up, the florescent tube glowed brightly, and the distant skywave stations said that our signal went from almost unreadable on the capacitive ground plane to signal strength seven on the sea water direct ground connection. We could also hear the difference on receive, too. The capacitive ground system gave us plenty of noise, but the sea water ground dropped on the onboard noise, and peaked the signal coming in from stations thousands of miles away on several high-frequency ham bands. The automatic antenna couplers were also much faster in their lock up to the sea water ground.

The final test was to see how much sea water contact we needed to achieve strong signal reports, minimum onboard noise pick-up, strong antenna current on the antenna, and a bright florescent tube. Our test would involve switching to the fourth copper foil hanging only four inches in the sea water. Guess what? There was virtually no change in performance as long as our copper foil ground was making just four inches of contact with the sea water. We have seen this phenomena many times — a single copper foil ground to a conductive surface like sea water, vehicle frame, and apartment chicken wire does the grounding trick completely without 1/4 wavelength radials needed.

We repeated the twin foils test several times — one foil ground over 30 feet into the sea water, and the other foil ground just inches below the sea water surface. Signal reports were identical. The tuner would not change tuning steps between the two as further proof that the tuner could not sense four inches of sea water grounding, or almost 40 feet of sea water grounding with 3" wide copper foil.

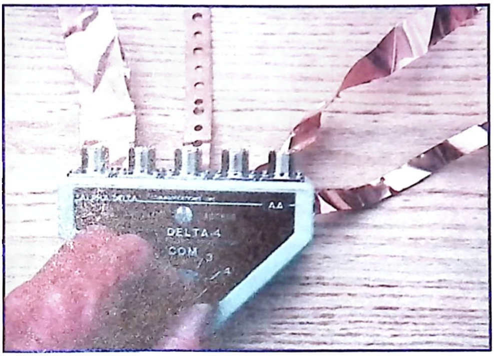


SGC automatic remote-mounted antenna coupler — inside view.

ANTENNA COUPLER DIFFERENCES

We have worked for years with the SGC automatic coupler — SG-230 — in both marine, mobile,

Radio pioneer Art Godson W7AEG verifies tuner output current over sea water ground.



Testing how well each tuner worked with different marine ground systems.

and aeronautical mobile applications. The SGC-230 can handle up to 200 watts of power, and will even let it tune very small three-watt transceivers like the Yaesu FT-817. But this is a big box — and is designed specifically for permanent installation, inside or outside. It is fully waterproof.

SGC now offers the dramatically smaller but fully waterproof Model 237 fully automatic antenna coupler, designed for fixed, portable, and weather protective applications. Like the larger SG-230, the SG-237 series outputs to an active long-wire antenna or the mounting of a portable whip antenna. They also offer the SG-231 slimmer version that might also work up to the amateur radio six-meter band.

Most recently, SGC brought in the SG-239 fully automatic antenna coupler, designed for any application mounting but the need for keeping rain or snow from getting into the exposed circuit board. The exposed section of the circuit board offers little tiny micro switches, push-button style, to manually accomplish the tuning process that is normally done fully automatically. There are literally hundreds of combinations that may be push-button controlled, and the SGC website shows them all!

All of the SGC automatic antenna couplers tuned up our sailor's insulated backstay with just three watts of power, the Yaesu FT-817, plus several other rigs including the SGC-2020, and we really couldn't tell any major difference on both transmit and receive. But I would assume that the physically larger SGC-237 tuner will run cooler and never arc over during prolonged periods of transmit running PSK-31 or PACTOR II. With the physically smaller sized SGC couplers, I would suggest their use with low- or medium-power transceivers that won't necessarily exceed 150 watts output.

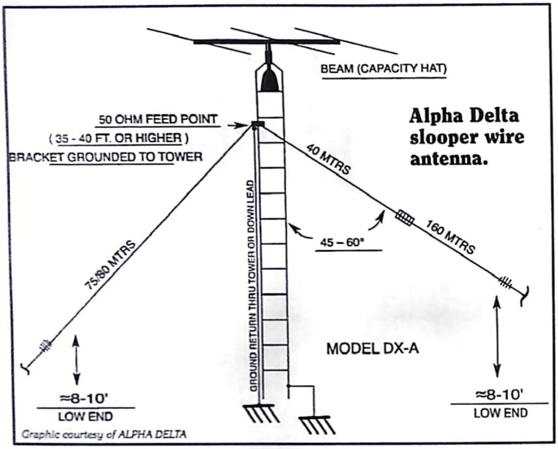
We then began testing a new line of automatic antenna couplers/tuners from LDG Electronics. We first tested the LDG Z11, an 1.8 MHz to 30 MHz device that works all the way down to one-tenth of a watt output and up to about 30 watts continuous, 60 watts peak. This tuner would be ideally suited for the new breed of QRP transceivers, not necessarily your big HF marine or ham set that typically puts out in excess of 100 watts plus.

The LDG Z11 was found to be extremely frugal on current consumption, going into a low-current mode of only .0079 amps after tune up. And sure enough, as soon as we gave the unit some forward power, the relays immediately began whirring and the green light-emitting diode blinked on showing tune with low SWR.

The Z11 is not intended for remote mounting as all the SGC automatic couplers. The LDG Z11 mounts by the equipment, and to start the tuning process, you transmit a continuous carrier and press the tune button. If you press the button with your equipment still in receive, you hear a momentary burst of noise in your receiver, and this is a good indicator for you to know you must first transmit the steady carrier and then push the button.

Since the LDG Z11 is at the equipment, not the antenna feedpoint, you are not only tuning the antenna, but also a portion of the coax feeding the antenna. LDG recommends a 4-to-1 or 6-to-1 balun between the antenna and tuner to facilitate

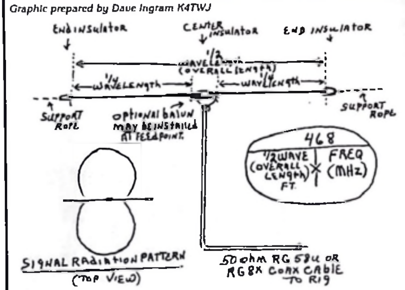
Little low-cost LDG Z-11 auto tuner.



Alpha Delta slooper wire antenna.

Graphic courtesy of ALPHA DELTA

Graphic prepared by Dave Ingram K4TWJ



Low-cost simple dipole works wonders!

the tuning process without putting an over amount of current onto a radiating feedline. We did find that transmit did cause some interesting squeaks and glows in the sailboat instrument panel, but we noticed our feedline was running relatively close to the panel, so we suspect it was a little bit of stray RF getting onto some of the ship's wiring.

The front panel of the Z11 has all sorts of switches so you may manually cycle the tuner into different combinations of inductance and capacitance for the best match.

We also tested the new IDG AT-11 MP automatic tuner with a built-in cross needle SWR bridge. This tuner also features coax output as opposed to a single-wire output featured on SGC automatic couplers. This means the AT-11 MP is placed right next to the equipment, and again it is recommended that a balun be installed at the feedpoint to improve performance. I might also recommend the Radio Works line oscillator to go at the feedpoint in maritime installations for both the Z11, as well as the AT-11.

The LDG AT-11 MP handles more power — up to 150 watts, using relays to configure 256 capacitors and 256 inductors and high-low impedance settings to provide over 130,000 tuning combinations. Most of our reviewers liked the cross needle S-meter and said it really gave them a good idea on how well the automatic antenna tuner was finding matches. We used the cross needle SWR meter also for determining how different ground systems aboard the sailboat would influence the tuner on different bands without the tuner automatically seeking a different combination of L and C.

An interesting feature we found was capabilities to tie this equipment into an ICOM 706. This would allow the ICOM tune button to switch over to CW, transmit 10 watts, and start the AT-11 MP tuning cycle. There are also capabilities of hooking in a speaker to jack 4 and audio feedback will provide an indication of SWR level. The feedback is a series of one to five beeps where one beep is low SWR, and five beeps indicates SWR above three. For the visually impaired ham, this might be a nice feature although any one of the pushbutton tuners could allow an operator to simply manually tune and listen to the amount of background noise. That was a nice touch with the audible feedback.

There is even a remote-control head that may be attached to the AT-11 MP. The remote hooks up via a nine-conductor shielded cable with a female dB-connector at each end. This could let you get the tuner closer to the antenna feedpoint.

Both the SGC, as well as the LDG automatic antenna couplers require 12 volts. For those of you running on batteries with the FT-817 or SGC-2020, power consumption is of primary importance to you, so you may wish to log onto both SGC, as well as LDG websites and see which automatic coupler is going to draw the least amount of power.

We didn't see much difference on our MFJ antenna current meter when we went to an auto coupler that was remote-mounted at the feedpoint to the LDG coupler that mounts by the equipment. We did find that the remote-mounted SGC auto couplers gave us less interference to our onboard ship wiring — but for a home station, chances are you wouldn't see the effects of elevated SWR on the feedline.

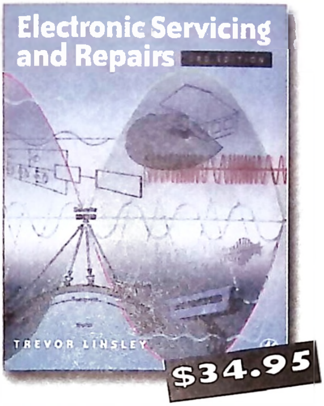
No doubt there will be great discussions between SGC and LDG on what type of tuning method is best — 50-ohm output, or a single-wire, high-voltage output right at the feedpoint. Weatherproofing is another consideration, and both SGC, as well as LDG are manufactured in the United States for USA factory service.

Chances are we're going to see more emphasis on relatively small automatic antenna couplers for the new breed of QRP transceivers. But keep in mind, as trick as automatic antenna couplers are, the homebrew dipole, cut to frequency, takes no additional antenna current and is a fun way to work DX from an antenna system you really feel good about because you designed and built it yourself.

But in special applications like maritime mobile, aeronautic mobile, or when you have a single wire with multiple bands of necessary operation, automatic antenna couplers that tune well beyond the capabilities of built-in automatic antenna tuners are a logical choice. **NV**

Next month: HF Antennas Shootout. How much better are bigger coil mobile antennas?

New Books



Electronic Servicing and Repairs

(3rd Edition) by Trevor Linsley

This is a new edition of the successful Electronics for Electricians and Service Engineers and completely updates the previous text by taking into account the recent changes in the C&G 2360 (now 2351) and 2240. The new edition also incorporates hardware topics from the popular course, C&G 7261 Information Technology making this an indispensable reference for all those taking C&G courses.

'Electronic Servicing and Repairs' includes an expanded chapter on testing and fault diagnosis, incorporates PLCs and CAD software and introduces automatic text equipment (ATE). Communication and security systems are completely updated — the section on TV receivers, satellite TV, VCRs, CD players, and cable TV has been expanded and a new chapter has been devoted to alarm systems.

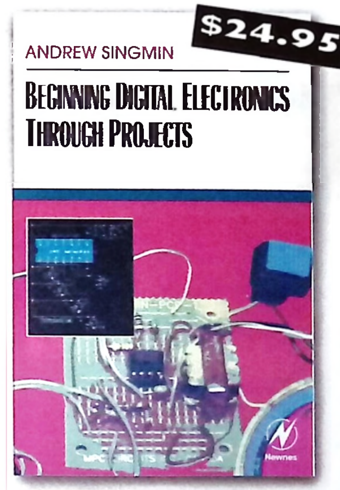
Contents

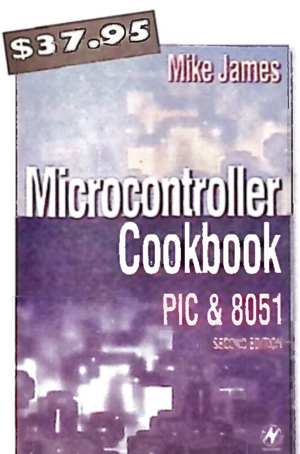
Health and safety * Electronic component recognition * Electronic circuit assembly techniques * Electronic semi-conductor devices * Electronic circuits in action * Testing electronic circuits * Digital electronics * Electrical circuit theory * Electronic systems * Communication systems * Security systems * Sensors and transducers * Appendices * Glossary.

Beginning Digital Electronics Through Projects by Andrew Singmin

Beginning Digital Electronics Through Projects provides practical exercises, building techniques, and ideas for over 35 useful digital projects. Some digital logic knowledge is necessary, but the theory is limited to "need-to-know" information that will allow you to get started right away without complex math. Many components in this text are common to either analog or digital electronics, and beginners or hobbyists making their start here will find an overview of commonly-used components and their functions described in everyday terms.

Each of the projects builds on the theory and component knowledge developed in earlier chapters, establishing progressively more ambitious goals. Step-by-step learning instructions help you determine the best ways of working with such projects as Schmitt Trigger Circuits, Versatile ICs, Digital Support Circuits, and much more. Two interesting wireless projects (an FM receiver and an FM transmitter) bring the final chapters of this book to a close.





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Microcontroller Cookbook

(2nd Edition) by Mike James

Microcontroller Cookbook guides you through programming, interfacing, development work, and circuit design using two of the most popular microcontroller families. The cookbook approach makes this an ideal book for anyone who has to get up and running quickly, so it is ideal for hard-pressed professionals and advanced electronics hobbyists. Enough theory is included to make this a suitable text for introductory microelectronics courses up to first-year degree level. New sections of reviews make this an ideal text for courses or independent study.

Contents

Preface; Number systems; Programmable logic design; Memory systems; Input/output systems; Problem analysis and design; Text editor/assembler/linker operation; MCS51 hardware; MCS51 software; PIC hardware; PIC software; Development systems; Microcontrollers Vs SBC; Compilers; Problem solving in C; Index.

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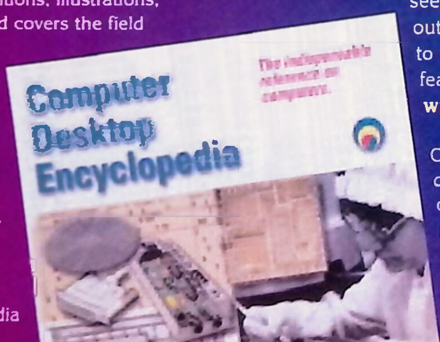

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by Dennis Shepard

Build Your Own Universal LCD Interface

Visual display devices are an integral part of electronics in this age.

Those of us who are a little older will remember the seemingly magical dawn of digital display devices several decades ago. The first digital voltmeter I remember seeing actually had rows of incandescent lamps numbered 0-9 for each decade of the digits! Then, it began with the seven-segment LED readouts and has progressed to the multiple-sized LCD displays of today. And it really gives a professional appearance to any project you might come up with.

A quick look at almost anybody's surplus or electronics catalog will reveal some real bargains out there in LCD displays. The only problem is that an interface is required. The modules typically require set-up and configuration commands to be sent to the device to ready it for operation. And the interface is normally eight-bit parallel with several control lines to boot. So that could stifle the average user a bit ... until now.

What I've come up with is a simple serial interface that includes the most often desired features, as well as simplicity of use. Designed for use with one line by eight character LCDs all the way up to two lines by 40 character LCDs, the interface pretty well covers all the displays out there. Along with two different versions to operate at either 2400 baud or 9600 baud in a standard 8N1 format ... depending on what your speed requirements are.

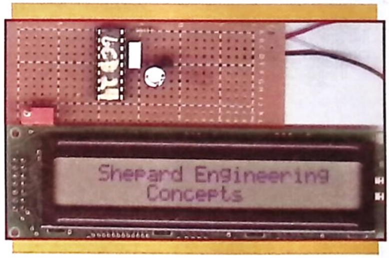
And only two software commands to simplify control ... a carriage return (Control-L which is ASCII code 12) to clear the display and a line feed (Control-M which is ASCII code 13) to reposition the cursor to the beginning of the second line. So, if you've been looking for a way to really jazz up your next project ... here it is! I think you'll find it's just what you've been looking for ...

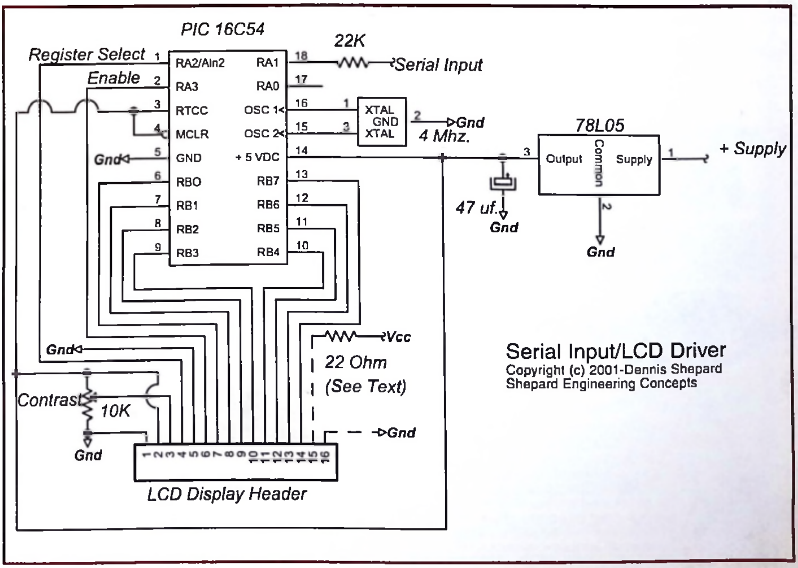
What makes it universal?

Good question. Most LCD displays available to the general public (and hobbyists, in particular) are based on the Hitachi HD44780 LCD interface chip. Since these displays use the same protocol based on this IC, it's possible to make a universal interface that works well with many different displays. And there's some other commonalities, as well.

LCDs are alpha-numeric and display a full range of characters known as ASCII, which stands for American Standard Code for Information Interchange. Based on an eight-bit code (that's why they have eight data lines), the displays will show numbers, letters in both upper and lower case, and graphics characters. Since the codes for the numbers and letters (as well as the control codes) are universal, we know that sending the proper code will always generate the proper character.

LCDs are always set-up with 80 memory locations. Since we have configured the set-up procedure for two-line displays, the first line goes from memory locations 1-40 and the second line starts at memory locations 41-80. So, if you've got a 2x40 LCD display, you can see all 80 locations at once. We'll go into this





What I've come up with is a simple serial interface that includes the most often desired features, as well as simplicity of use.

Universal RS-485 Serial Link Interface

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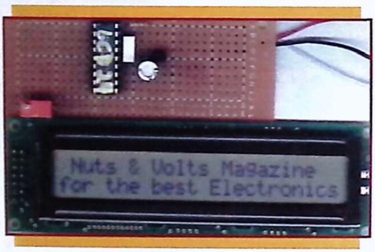

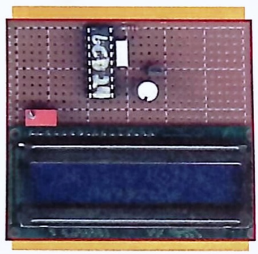

more later, but I wanted to touch on it here as part of the standard which LCD manufacturers follow.

LCD displays have great advantages over LED displays in several ways. When was the last time you saw an LED watch or calculator? LCDs use less power, generate less heat, and are easily viewed in many different lighting conditions. Some LCDs have backlighting, which allows them to be viewed in darkened environments! And most LEDs are limited to a seven-segment readout, which limits you to numbers only.

Initializing the display

This is where it gets interesting. Besides the eight data lines, LCD modules will also have three other control lines. There's an R/W line, a Register Select line, and an Enable line. The Read/Write line is grounded in this project since we're not interested in reading any information from the LCD. The register Select line allows us to switch from command mode to data mode. And the Enable line determines when the LCD display receives the commands or data.

On start-up, the LCD display goes through its own initialization routine. This takes approximately 15 msec., during which time the display is said to be 'busy.' The first thing we do in the PICs program is to change all I/O lines connected to the module to inputs. This prevents any interference with the display's start-up routine. Then we change the I/O lines to outputs and set the Register Select and Enable lines low.

This puts the display in command mode. The display is then programmed for eight-bits, 5 x 7 format, second line on and enabled by toggling the enable line high and low again. Next, the display is turned on and the enable line is toggled. Finally, the display is cleared and the enable line is toggled again. Now, we set the Register Select line high, and we're in the data mode of operation and we're ready to do something.

The dreaded numbers game

Well ... it's not really that bad! If you'll recall, we discussed earlier about how all LCD modules have 80 memory locations. But unless you've got a 2 line by 40 character display, you're going to reach a point where you send characters to the display and nothing shows up. We're about to solve that mystery right now!

For example, a two line by 16 character LCD display will use memory locations 1-16 for the first line. If you keep sending characters,

LCD displays have great advantages over LED displays in several ways.

Universal LCD Serial Interface — Parts List

C1 — 47 uF 35 WVDC electrolytic capacitor, **RadioShack** #272-1027 or equal
*CR1 — 4.00 MHz Ceramic Resonator, **Digi-Key** #PX400-ND or equal
*IC1 — **Microchip Technology** PIC 16C54-XT/P microcontroller **Digi-Key** PIC 16C54-XT/P-ND (requires programming)
POT1 — 10K ohm 15-turn potentiometer, **RadioShack** #271-343 or equal
R1 — 2K ohm 1/4W 5% carbon resistor, **RadioShack** #271-1339 or equal
*VR1 — 78L05 5 VDC 100 mA voltage regulator, **Digi-Key** #78L05ACZ-ND or equal
Misc. — 0.1" male headers, hook-up wire, etc.

*The following items are available directly from Shepard Engineering Concepts. A kit of programmed IC1, CR1, and VR1 are available for $15.00 ppd. These prices are for the continental US only. Please make payment to: **Dennis Shepard, 8315-D Laborough Drive, Bakersfield, CA 93311.** Payment methods preferred are money orders, certified checks, or Western Union.

they'll occupy memory locations 17-40, but they won't be displayed because the second line of the display doesn't start at memory location 17, it starts at memory location 41! That's why I've included the line feed command to send the cursor to memory location 41. This puts you in the first position of the second line.

The carriage return command erases all 80 memory locations, clears the entire display, and moves the cursor to memory location 1. All LCD displays automatically increment and display characters from left to right. The only catch — as we discussed earlier — is this memory location thing. So now, you can use this format with any LCD display and manipulate the cursor and characters to suit your needs.

Since you already know how many characters and lines your display will be using, you can send one of two commands to position your characters where you want them. And even overwrite the second line without touching the first! I think it's a rather simple solution to what others have presented as complex in the past. In other words, it doesn't have to be complicated to be useful.

Long distance for under a buck

No ... we're not selling phone cards! A lot of times it's required to send information to be displayed to a remote location. Serial standard EIA/TIA RS-232 is designed for about 50 feet. However, there is an inexpensive solution. National Semiconductor — among others — makes a 75176 that is an RS-485 transceiver chip and it sells for less than a buck apiece! RS-485 is a balanced transmission medium that's good for over 4,000 feet (over 3/4 of a mile!) using a single twisted pair of #24 AWG wires.

Basically, we wanted to include this information in case you needed it. But, you certainly don't have to use it. The circuitry

In other words, it doesn't have to be complicated to be useful.

9600

```
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2400

```
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```

shown in the schematic uses two 75176s ... one set up as a transmitter and the other as a receiver. The data is simply converted from TTL level to RS-485 ... transmitted ... and converted back to TTL levels at the other end. And, of course, you could tie a RS-232 chip, such as a MAX 232 from Maxim, to change to and from RS-232 in the process, should you need that as well. Lots of options, but better too many than not enough!

The circuitry itself

There are two standard configurations for interfacing an LCD module. Manufacturers either use a single row of 14 or 16 connections or sometimes use a double row of eight connections. Because the pinout configuration and the location varies from manufacturer to manufacturer, it didn't seem prudent to design a PCB that may or not work with your display. But we are going to cover the pinouts, which are universally accepted. They are:

Pin#	Function
1	Ground
2	+ Power Supply
3	Contrast Adjust
4	Register Select line
5	Read/Write line
6	Enable line
7	Data Bus 0
8	Data Bus 1
9	Data Bus 2
10	Data Bus 3
11	Data Bus 4
12	Data Bus 5
13	Data Bus 6
14	Data Bus 7
15	Backlight Anode (if applicable)
16	Backlight Cathode (if applicable)

The actual circuitry is pretty straightforward. A PIC 16C54 converts from serial to parallel data format and handles all control line functions and the LCD module's initialization, as well. A potentiometer is used to adjust the LCD contrast. If you've got a backlight LCD, pins 15 and 16 supply the power to that function. Typically, a 22-ohm resistor is used to limit current, but you might want to check with the manufacturer of your particular unit for their recommendation.

The 22-ohm resistor is shown with dashed lines on the schematic. It's an optional component since it isn't needed on non-backlit LCD displays. A 22K resistor is used in series with the input to interface directly to RS-232 circuits.

The internal diodes, which protect the inputs of the PIC, will clamp the input voltage to around 5 VDC and this resistor will limit the current, thus protecting the PIC itself. Since we've already covered the operational sequence on startup in the initialization procedure previously, there's no need to repeat it again.

Wrapping it up

I hope you're going to have as much fun with this as I did! I evaluated two different modules for this project and I consider both of them a good value for the money. I can't guarantee their availability although both suppliers indicated that they expected an ample supply to be available for a while.

All Electronics in Los Angeles, CA (1-800-826-5432) has a 16 character x two line LCD module (part #LCD-53) with backlight which is available for only $7.50. This module uses a 16-pin SIP layout and works well with the 22-ohm resistor shown in the schematic. But remember, although a backlit display lets you see at night, it also consumes more power, so it might not be your best application for battery-operated equipment

MPJA in Lake Park, FL (1-800-652-6733) has a 24 character x two line LCD module (part #12856-OP) which is available for only $8.95. This display uses an Optrex DMC24227 and uses the double row 2 x 8 pin connector, even though it doesn't use pins 15 and 16 since it's not a backlit display. A ribbon cable is probably a good option for interfacing to this display, while a 16-pin SIP header is probably best for the other unit. I think you'll be happy with either display, depending on what your requirements are.

A programmed PIC is available for $15.00 and includes a 4 MHz ceramic resonator and a 78L05 voltage regulator. Please remember that the regulator is only rated for 100 mA output current so it's probably not going to supply enough current for both the electronics and the backlighting, if required. Please keep that in mind when interfacing to your project. A 7805 voltage regulator is rated for 1.5 amperes (with a heatsink) so it might be a better choice for backlit displays.

Once again, I hope I've taken some of the mystery out of LCD displays and how useful they can be to your own projects. I've got several projects in the works that will make use of serially interfaced LCD displays. Because of this, I decided a little introduction would be helpful and whet your appetite for bigger and better things yet to come.

Enjoy ... **NV**

Stay tuned for more articles from Dennis which use LCD modules, including an Energy Monitoring System and a 20-channel Digital Wire Tracer.

Laser Insight

by Stanley York

This month, we're going to take a break from all the theory and technical stuff. We're going to start a construction project that I promised you earlier. The project is for a light show that you can use with a HeNe laser or a diode laser pointer. There will be a few optional add-ons for this project that can be built later as your time and budget allow.

First, I'll briefly describe what the light show will let you do, then we'll look at the details of all the bits and pieces that make up the whole.

The laser can be any HeNe that you can pick up at surplus stores, hamfests, etc., or it could be one of those laser pointers that you see quite a lot of these days. Edmund Scientific (Barrington, NJ; (800) 363-1992) has a good selection of laser diodes, as well as the larger HeNe lasers, so you should be able to find something there that won't break your bank. Be prepared to spend more if you want anything other than the standard red color though. Always keep in mind, that even though they are small and battery-operated, the little pointer lasers are just as dangerous to the eyes as their bigger counterparts. They won't blind you, but it will feel as though someone jabbed a finger in your eye.

Light show description

The basic light show as described will allow you to connect your stereo to the mirror drivers to create weird, non-repeating patterns on a wall or ceiling that changes in response to the musical content. Alternatively, there are inputs to allow a function generator to drive the mirrors. This will create steady or slowly changing patterns that vary according to the types of inputs to the two channels. Or you could mix the oscillator and music inputs to get really bizarre effects.

Optional equipment will allow circular and epicyclic patterns to be generated in addition to the patterns corresponding to the audio input. Finally, there will be a chopper system described that will modulate the laser beam to form dotted lines instead of the more familiar continuous lines. All of these effects can be operated independently or in unison, making the unit very versatile and far from boring. If two lasers are used – each a different color – and mixed going into the unit, the results will be even more impressive.

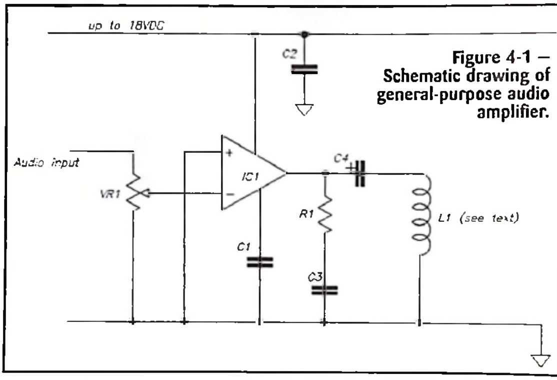

Figure 4-1 – Schematic drawing of general-purpose audio amplifier.

Before we start

To begin building the light show, we will need to gather some parts that may be hard to find. These are the scanner mirrors used to deflect the laser beam. They are rather special, and quite expensive if you have to buy them new. In my system, I used some scanners that I picked up at a surplus store here in Orlando, where I live. You should shop around in your neighborhood to see if there is a surplus store near you. The scanners I used were made by General Scanning (Watertown, MA).

If you have a hard time finding these devices, I will describe a simple method whereby you may try to make your own. Of course, they won't be as good as proper scanners, but the fun and satisfaction with this hobby is making something out of nothing, and making it work! If you are anything like me, you'll take the challenge, and make some scanners. So get that pioneering spirit going.

The driver amplifier for these scanners is shown in Figure 4-1. As you can see, it is a very simple circuit based on a readily available IC. Nothing is critical about the circuit, and you are free to experiment with other ICs.

I chose an LM384 because that's what I had in my parts box, but again, nothing is chiseled in stone here, so go ahead and experiment. You may find that the scanners you end up with may need more power (or less), so don't dwell on the schematic.

You will need two of these amplifiers to drive the scanners though, so try at least to make the two circuits the same, so that you

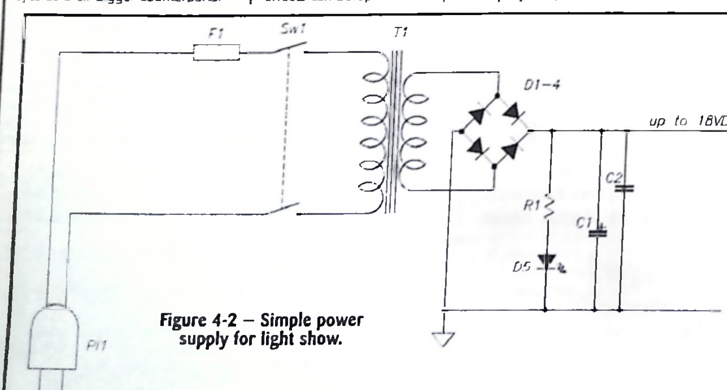

Figure 4-2 – Simple power supply for light show.

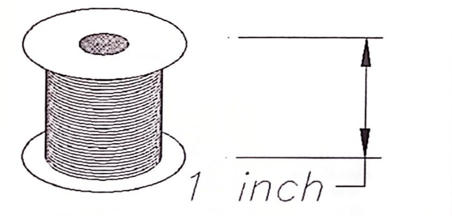

Figure 4-3 — Details of coil.

get equal laser beam deflection characteristics.

In this drawing, L1 is the scanner coil, and should be made such that the coil impedance is similar to a loudspeaker. VR1 acts as a volume control, and is used to scale the size of the projected light patterns. The input signal may be derived from an audio source, a signal generator, or both, using suitable mixing means on the input control circuit (not shown). Nothing is critical in this set-up, and you are free to experiment.

A suitable power supply for driving the amplifiers is shown in Figure 4-2. Again, there is nothing critical about this circuit, but keep in mind the limitations imposed by the amplifiers and scanners you intend to use in your set-up.

Don't use a power supply that is too close to the limits of either, or you'll be inviting trouble. Make sure the transformer can deliver the required power, and that the diode bridge can handle the current. Maximum draw on this unit, with all the options added, should not be more than about 2A. Loud passages of music may cause a peak current of about 3A; depending on how the volume control (VR1) is set. D5 is a red LED used to indicate that the power supply is on. The resistor R1 should limit the LED current to about 15-20mA.

When using main powered equipment, you should always use a double-pole switch to break both lines coming into the equipment. Then, if the connections at the wall socket are miswired, there is no shock hazard when the power is turned off using the switch. Note also, that the fuse is first in line. If the fuse blows for some reason, power is removed from the switch. If the situation were reversed, and the fuse blows, then the switch will still be live. This presents a serious shock hazard when the fuse is located internally to the equipment rather than through a chassis fuse holder. So play it safe.

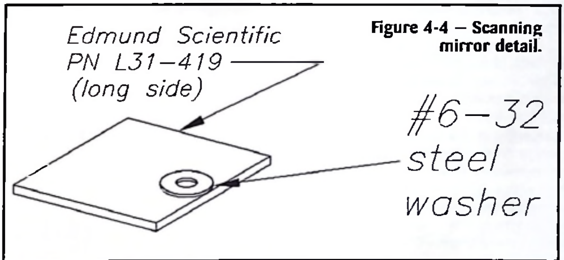

Figure 4-4 — Scanning mirror detail.

Scanner basics

If you haven't had an opportunity to use scanners before, I'll give you a bit of information about them before we set about making some.

Imagine if you will a simple battery-operated electric motor. Imagine a mirror glued to the shaft of the motor, such that the mirror surface is parallel to the shaft.

Now imagine the motor rotating, and a laser beam directed at the shaft. Each time the mirror presents the silvered side in the general direction of the laser beam, the reflected beam will describe an arc around the room that is at some angle to the rotating shaft.

Now imagine what would happen if the shaft were fixed at one end. The motor would try to turn the shaft against the torsion of the fixed end. The amount of rotation on the shaft would thus be dependent on the torsional strength of the shaft and the strength of the magnetic field trying to turn it. This is exactly the way scanners of the type I use in my system operate.

Commercial scanners are designed with a very thin shaft, fixed at one end, and with rotor coils similar to a normal motor at the other end. When power is applied, there is more or less turning of the shaft at the end where the rotor coils are, depending on the torsional rigidity of the shaft and the strength of the magnetic field trying to turn it. The amount of turning is thus proportional to the current strength in the rotor coils.

Commercial scanners can only move through a very limited angular motion, but they can be made to move very fast, and in an upcoming article, I will describe how they are used in high-speed laser engraving applications.

Okay, that's how commercially-bought scanners work, but we can't possibly make anything to compare with those. Not on our limited resources, anyway. Our scanners will be simpler, though not as effective. But they will illustrate the principles of scanners and light show systems in particular.

Making the scanners

As I said before, I happened to find some surplus scanners in a local store here in Orlando, but for those less fortunate, I will describe now how we can make a poor man's version of the scanner. You will need two of these scanners for the project. There are a number of ways of doing this, and I will describe one simple way. After trying this, you may find other (perhaps better) ways of achieving the same thing.

Figure 4-3 shows a wire spool wound with magnet wire that is used as the deflecting means for

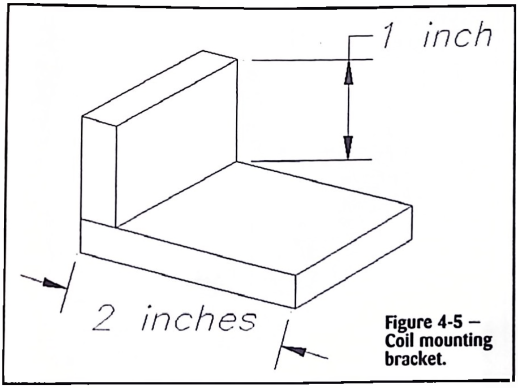

Figure 4-5 — Coil mounting bracket.

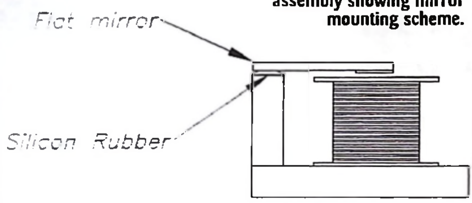

Figure 4-6— Scanner assembly showing mirror mounting scheme.

our scanner. I wound this with #26 gauge magnet wire until the spool was full. When I measured the resistance of the coil, it was about four ohms. The coil was about 3/4 inch in diameter and about an inch high.

The strength of the magnet is not much at this point, since the coil has no core. To improve the strength, I found a number of small iron nails and cut off the heads and jammed them into the opening in the core until I could get no more in. Then I secured them with a dab of silicon sealer left over from a plumbing project. I pushed down on the nails so that there was a little (about 1/16") of the nails sticking out on one side.

Turning next to the mirror, I had a mirror left over from another project that I had obtained some years ago from Edmund Scientific. This was a thin mirror that I had to cut in half to reduce weight, and stuck a flat washer to the underside of the mirror on one of the short sides (see Figure 4-4). The washer is used to pull the mirror toward the magnet in the final assembly of the scanner. Use epoxy to stick the washer on. Use a small dab, and don't get any on the top of the washer. Place the washer close to the edge on the short side.

Find a scrap of 1/4-inch thick Plexiglas and make two of the small angle brackets shown in Figure 4-5. These will be the scanner mounting brackets when we're done. Use plastic cement or epoxy to assemble this part. The dimensions are not too critical, but you need to get the finished height of the bracket the same as the height of the coil in Figure 4-3. Place a couple of dabs of silicon rubber sealer on the top edge of the Plexiglas block and place the mirror on the sealer as shown in Figure 4-6. Alternatively, you may find that rubber cement works okay too, if you build up a few layers. I haven't tried it yet.

Either way, you will need to hold the mirror off the surface of the Plexiglas, otherwise it won't be able to flex when the coil pulls on it. When the sealer dries, it acts as a spring against the pull of the magnet, so that the stronger the magnetizing force, the greater is the deflection on the mirror.

Put a dab of sealer on the base of the mounting block and position the coil so that the core of the coil is directly underneath the washer glued on the back of the mirror. While the silicon sealer is still tacky, slide a piece of thin card between the core of the coil and the back side of the mirror. You should try to get about 1/16-inch space between the flat washer and the top of the magnetic core when the assembly is finished. Figure 4-7 shows a completed scanner assembly.

Take a look now at Figure 4-8. This shows the general layout of the various scanners, and the path that the laser beam takes on its passage through the system.

In this installation, the laser beam is coming in from the left of the page. At this point, I have only mentioned the two scanners we have just finished building. But there are two more scanners, consisting of circular (or square) mirrors epoxied to the end of two motor shafts. I'll discuss these more later. If you prefer, you can leave out these two scanners until you have the homemade scanners working to your satisfaction.

The laser beam comes in from the left and strikes the first scanner mirror approximately in the center of the glass. The first scanner deflects the laser beam in a vertical direction. The reflected beam then strikes the second scanner mirror approximately in the center. This scanner deflects the beam in a horizontal direction. Note that the two scanners here are mounted so that the deflection angles are perpendicular.

With the simple arrangement described, it is possible to put the laser spot in any position in a square area corresponding to the four maximum deflection positions of the mirrors. If quadrature sinewaves (that is sinewaves that are 90° out of phase) were delivered to the scanner coils, the resulting pattern displayed on a wall or ceiling would be a circle. If sinewaves of different frequencies were delivered instead, the resulting display would be the familiar Lissajous patterns.

On their own, these two scanners would give quite an interesting display that would not repeat or become static if used with speech and music inputs to the amplifiers. But the addition of two more scanners, as depicted in Figure 4-8, make the display even more interesting.

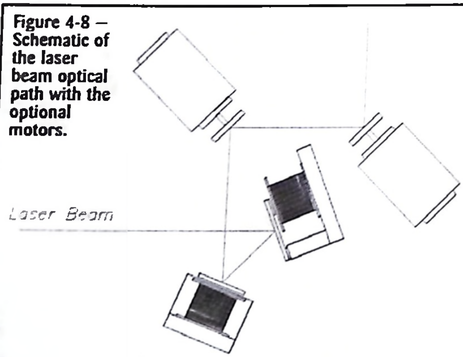

Figure 4-8 — Schematic of the laser beam optical path with the optional motors.

Rotating scanners

The two other scanners shown in Figure 4-8 are simply small electric motors with mirrors epoxied to the end of the shaft. The mirrors are purposely not epoxied perpendicular to the shaft, though, otherwise the displayed beam will not move when the motor is running.

Get some pieces of mirror about an inch across, and put a dab of epoxy in the center of the back side. Place the mirror on the end of the shaft and support it while the epoxy sets. Try to get the mirror almost perpendicular (a couple of degrees off is okay). When the epoxy sets, turn the assembly over and reinforce the glued joint with more epoxy. (You don't want the mirror to go flying across the room do you?)

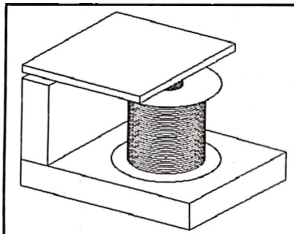

Figure 4-7 — Completed scanner assembly.

With two circular scanners as shown, you will be able to create circular patterns, and circular patterns within the main circle. If you had a Spirograph™ as a kid, you've probably heard of cycloids and epicycloids. By running the motors at different speeds, the two circular scanners will allow you to create similar patterns to those first encountered playing with this toy.

Figure 4-9 shows a suggested layout and method of mounting everything onto a simple fixture. Use 18 AWG aluminum sheet for mounting the two scanners, and use plastic or rubber "P" clips for holding the motors. Rubber works good because it has a little 'give' to it, and will help absorb some of the vibration from an out-of-balance motor. As shown, the device will display images onto the ceiling, but can easily be turned around to display on a wall, if desired.

If you want to add one more special effect not shown or discussed thus far, you may want to consider adding another small motor with a chopper wheel attached to its shaft. This will be a simple disk of stiff card or plastic, with a series of holes drilled or punched equally spaced around the

edge of the disk. The disk is attached to the motor shaft in a similar way to the rotary scanners discussed before, but this time try to get the disk perpendicular to the shaft.

Mount the motor similarly to the previous motors, but position it such that the laser beam goes through one of the holes in the disk before striking the first mirror. When this motor is stationary, you will get a continuous line pattern. But when the motor is turning, you will get a dotted line pattern.

As an alternative method of making scanners on the cheap, consider using an old set of bass speakers. Bass speakers work best because they are capable of greater linear displacement than the scanners described above. The usual method is to glue a mirror to the side or bottom of the paper cone, but there are better ways of attaching the mirror without changing the frequency response of the speaker.

All of these scanners and the chopper wheel may be run together or independently through pulse generators, sinewave generators, and audio sources of any kind to create an almost inexhaustible variety of patterns and effects.

Caution

Finally, I can't let this article go without a word of caution.

Whether you use a laser diode or a more powerful HeNe laser, the fact remains that the light coming from the laser is very intense and concentrated, and thereby constitutes a real danger to the unwary eye. The light will damage the retina of the eye. When using this device, or any other device using a laser, ***please, please, please be very careful***. Especially if your audience is unaware, or perhaps too young to understand the dangers of laser light.

Make sure that the beam falls safely away from anyone in your audience, and strikes a flat (not glossy or shiny) surface, then the beam cannot reflect back into their faces (or yours). It is easy to be complacent when dealing with these devices, thinking that they are safe because of the low power output, but don't be lulled into a false sense of security. You only have one set of eyes, and they have to last you a lifetime, so don't take any chances. NV

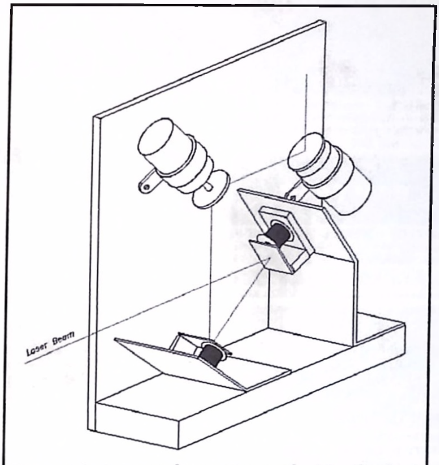

Figure 4-9—Suggested mounting method for the dual scanner light show (see text for details).

This column welcomes your participation. If you have questions, comments, or perhaps an idea for a future project, please let me know through this column. Any ideas or suggestions are welcome. You can email me at stanley.york@att.net.

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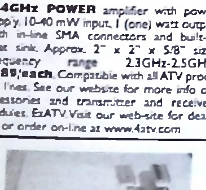

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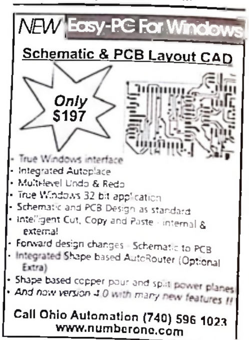

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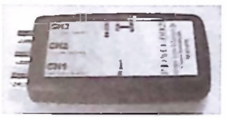

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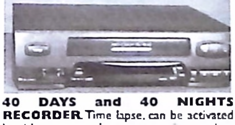

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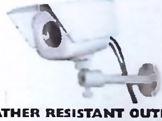

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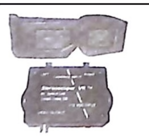

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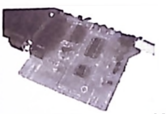

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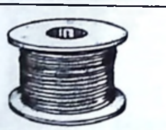
HARD-TO-find parts: PTV screens, modules, chassis, flybacks, tuners, tubes, for all brands. Manuals. 478-272-6561. Scarborough TV, 1422 Old River Road, East Dublin, GA 31027. scarboroughstv@pcnow.net

HIGH QUALITY TOOLS AND STAINLESS STEEL HARDWARE. European and American screwdrivers, nutdrivers, pliers, hex-keys, balldrivers, and more! Wiha, Bondhus, and Knipex. Stainless cap screws, machine screws, nuts, washers, U-bolts, and eyes. Free catalog. Robert Mink Import-Export, Box 6437V, Fair Haven, NJ 07704. Telephone or fax 732-758-8388. E-Mail: w2tv@compuserve.com

SOLAR-POWERED FAN HAT. Baseball type hat with solar powered fan. Great for sports fans, golfers, etc. Available in red or blue. $19 plus $2.00 shipping. CA residents add 7.75% sales tax. Visa/MC/Disc/Amex OK. H.T. Orr Computer Supplies, 249 Juanita Way, Placentia, CA 92670. 714-528-9822, 1-800-377-2023, FAX 714-993-6216.

FOR SALE: Transmission Equipment. (2) 2.4 meter channel master send/receive dish with Prodlin non-penetrating mount. (2) 8 watt transmitters, Sierra Com w/o controller. (2) 1.8 meter channel master dish w/channel master (Baird) non-penetrating mount. (2) sky data RF hoods w/IFL boxes 4 watts each. (1) 2.4 meter Prodlin dish w/o mount. Contact: Bob Newstead 480-948-0586 or Morris Scott 602-307-0180. Equipment located in Scottsdale, AZ. Buyer responsible for removal.



ANAHEIM WIRE PRODUCTS. DISTRIBUTOR OF ELECTRICAL WIRE AND CABLE since 1973. Items available from our stock: Hook up wire, Automotive primary wire, GXL, SXL, Plenum cable, Teflon wire, Multi-conductor cable, Irradiated PVC, SO-CORD, Mil-Spec wire, Building wire, Welding cable, Battery cable, Telephone wire, Shrink tubing, Cable ties, Connectors. Wire cut & strip to specs. If interested, please call **1-800-626-7540**, FAX: 714-563-8309. Visa/MC/Amex. SEE US ON THE INTERNET: http://www.anaheimwire.com OR E-Mail: info@anaheimwire.com

FOR SALE: Heathkit, other test and audio equipment and miscellaneous. 36 items. LSASE for detailed list. Richard Flaws, 212 Mondovi Drive, Oswego, IL 60543-8408.

Computer Desktop Encyclopedia

Online *Now* at
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For Experts and Novices – The Encyclopedia contains more than 15,000 definitions, illustrations, photos, charts and diagrams, and covers the field from micro to mainframe.

Twenty Years in the Making – Starting as The Computer Glossary in 1980, the Encyclopedia is the longest-running computer dictionary. Edited by Alan Freedman, noted computer lexicographer with 40 years of experience in the industry, the Encyclopedia is the most comprehensive reference of its kind.

NUCLEAR ELECTRONICS (NIM, CAMAC), PMTs, optics, high vacuum, and high voltage components and equipment. Guaranteed quality at reasonable cost. OE Technologies, Box 703, La Madera, NM 87539. Ph: 505-583-2482, Fax: 505-583-9190, E-Mail: oetech@newmexico.com http://www.oetech.com

MISCELLANEOUS ELECTRONICS WANTED

DEC EQUIPMENT WANTED!!! We are buying DEC systems, boards, terminals, drives and peripherals. Also Scientific Micro Systems (SMS), CMD, Datability, Dilog, DSD, EMULEX, other DEC compatibles. Please contact us for a quote or fax/email your equipment list. We buy, sell, and trade. **KEYWAYS, INC.**, 937-847-2300 or fax 937-847-2350 or email buyer@keyways.com

WANTED: TUBES, radios, transmitters, receivers, gyros, bearings, connectors, relays, lamps, synchros. Hyness Company, 709B Delair Road, Monroe Twp., NJ 08831. Phone: 609-395-1116, FAX 609-395-1117.

WANTED: BALANCING machines & vibration analyzing equipment manufactured by the following: Spectral Dynamics, Hofmann, Bentley Nevada, Schenck, IRD Mechanalysis, Gishott. Contact Mike Park at E.T. Balancing, 12823 Athens Way, Los Angeles, CA 90061. 310-538-9738, FAX: 310-538-8273.

CASH PAID FOR ICs. Military or commercial integrated circuits, transistors, diodes, any semiconductors. **ELECTRONIC SURPLUS, INC.**, 5363 Broadway, Cleveland, OH 44127. 216-441-8500 or fax 216-441-8503, since 1946. www.electronicsurplus.com

WANTED: EXCESS ELECTRONIC COMPONENTS, BOARD-LEVEL COMPONENTS; MILITARY COMPONENTS; ICs, MEMORY, TRANSISTORS, DIODES, CAPS, RELAYS, ETC. CALL LPS 562-439-2453 FAX 562-439-0453.

WESTERN ELECTRIC wanted: 1920s-1960s. Amplifiers, mixers, pre-amps, speakers, tubes, etc. FREE OFFER 1-800-251-5454.

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WWW.8LINERS.COM YOUR Cherry Master & 8 liners website.

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MAGICIAN IS available to solve your RF problem. I will teach you in my laboratory how to do it. Young engineers and technicians are welcome. SMT prototyping up to 3GHz for customers. Minaret Radio, John Horvath ph: 909-943-3676.

BUSINESS OPPORTUNITIES

AFFILIATES WANTED: If you have a website you can earn a 10% commission for every person that you refer to our site. See complete details at www.spousewatcher.com

REPAIRS — SERVICES

(E)EPROM PROGRAMMING done quickly and economically. One day turn around typical. Simple copy $3 per device. Also prototyping, design, and consulting services available. Call or send SASE to: **Luzer Electronics, 4023 North Bayberry, Wichita, KS 67226. 316-687-2127, FAX 316-687-3103.**

CIRCUIT BOARDS for projects, prototypes, short runs. From your artwork. Low rates. Atlas Circuits 704-735-3943. www.pcbatlas.com

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MECH ENGINEERING CONSULTING: machine design & packaging from conceptual to manufacturing: detailing, bill of mat'l, part procurement, & proto build. **GSC, MECHANICAL ENGINEERING SERVICES 508-339-7837** or email: SECGSC@aol.com. (Ask for Greg.)

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Choose a category for your ad from these classifications.

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- 85. Security
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- 95. Military Surplus Electronics
- 100. Audio/Video/Lasers
- 110. Cable TV
- 115. Telephone/Fax
- 120. Components
- 125. Microcontrollers
- 130. Antique Electronics
- 135. Aviation Electronics
- 138. Thermocouple Welder
- 140. Publications
- 145. Robotics
- 148. CNC
- 150. Plans/Kits/Schematics
- 155. Manuals/Schematics Wanted
- 160. Misc. Electronics For Sale
- 170. Misc. Electronics Wanted
- 175. BBS & Online Services
- 180. Education
- 190. Business Opportunities
- 200. Repairs/Service

Classified Ad Instructions

TYPE or PRINT your **ELECTRONICALLY RELATED** ad copy **CLEARLY (not all caps)** on a separate piece of paper. Spell out words when submitting handwritten copy. Calculate the number of words and multiply it by the appropriate rate (see RATE PER WORD section). Include any charges for **bold** and/or CAPPED words, any artwork costs that would be applicable, and/or costs for boxing your ad (explained below). Choose the appropriate classification for your ad(s) to appear in (see below). If no classification is indicated, it will be placed in Misc. Electronics or wherever we deem most suitable. **Enclose your name, address, phone number, and *Nuts & Volts* account number from your mailing label** (if available) for identification purposes. Include full payment – **CLASSIFIEDS RUN ON A PRE-PAID BASIS ONLY** – and mail your completed order to:

NUTS & VOLTS MAGAZINE
430 Princeland Ct., Corona, CA 92879.

RATE PER WORD

The ad rate for **current PAID subscribers** is **60¢** per word. All others pay **$1.20** per word. There is a **$9.00 minimum** charge per ad per insertion.

BOLD WORDS AND/OR CAPS

Words to be set in **bold** or CAPS are each 10¢ extra PER WORD. **BOLD CAPS** are 20¢ extra per word. The first two words of each ad are bold capped at no charge. Indicate bold words by underlining. Words normally written in caps (e.g., IBM) and accepted abbreviations such as VAC or MHz are NOT charged as all cap words. Use a two-letter abbreviation for states.

PHOTOS, DRAWINGS, BOXES

A photo or drawing may be run at the top of your classified ad for an additional **$10.00** (1" depth max.) for camera-ready art. No wording is allowed in this area. To **BOX** your ad, include an additional **$50.00** for copy-only ads, or **$75.00** for ads with art or photos. Photos may be emailed to classad@nutsvolts.com.

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You may email or fax in ad copy or changes before the closing date (5:00pm on the **5th**) using MasterCard or Visa. Include credit card expiration date, the name that appears on the card, a daytime phone number, and your *Nuts & Volts* account number. Email ad(s) to classad@nutsvolts.com or fax to 909-371-3052. Ads without credit card information will not be listed as received until payment is received in full. **WE DO NOT CALL, EMAIL, OR FAX BACK VERIFICATION OR QUOTES OF EMAILED AND FAXED-IN ADS.** For verification of emailed or faxed-in ads, please call 909-371-8497.

DEADLINE

Prepaid ads received by 5:00pm on the **closing date (5th of the month)** will appear in the following month's issue. Ads postmarked through the **5th**, but received after the closing date, will be placed in the next available issue. No cancellations or changes after the 5th. Cancellations and changes must be submitted in writing.

IMPORTANT INFORMATION

All classified ads are running copy only. No special positioning, centering, dot leaders, extra space, etc. is allowed. All advertising in *Nuts & Volts* is limited to **electronically related items ONLY**. All ads are subject to approval by the publisher. We reserve the right to reject or edit any ad submitted. We do not take ad copy or changes over the phone. We do not bill for classified ads. Repeat ads or ads run in multiple classifications within the same issue are allowed. Paid subscribers may run ads at the 60¢ rate only through their subscription expiration date. **NO REFUNDS.** Credit only. No credit for typesetting errors will be issued unless you *clearly* print or type your ad copy.

Getting Started On A Shoestring

by TJ Byers

Just getting started in electronics, but don't have access to a lot of equipment or money? If you have $50.00 and a desire to learn, then you have the beginnings of a new hobby.

For a limited time, Circuit Specialists will give you a CSI Techmeter DMM — worth $29.00 — for free if you place an order for $30.00 or more. To qualify for this offer, you must enter the code "DMM FREE" on their web site when placing your order.

Hey you, over there, the newbie. You say you want to get started in electronics as a hobby, but don't have a lot of money? Yet, you want to work with programmable devices like a PIC or BASIC Stamp?

Fortunately, it doesn't take a lot of cash to get started, just a few basics that you can buy and/or build for about $50.00. Let me take you along the yellow brick electronics road to a land of fun and fantasy.

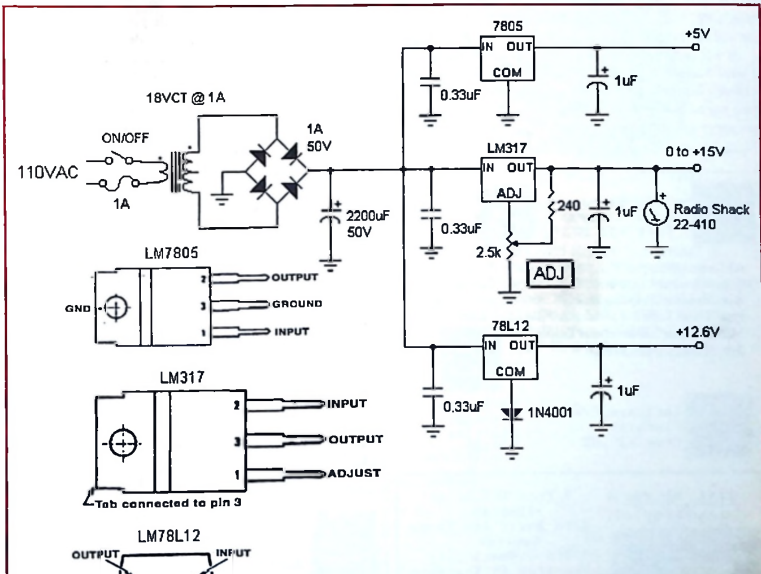
Test Bench Equipment Basics

First, you need a multimeter: a device that measures voltage, current, and resistance. It can be either analog or digital. Personally, I use the 9300G Digital Multimeter that I purchased from Circuit Specialists (800-528-1417; www.web-tronics.com/9300g.html) for just $19.00 any time, any day. Besides the basics, this gem includes a transistor and a diode checker. At the moment, as a special promo offer for *Nuts & Volts* readers, if you purchase $30.00 or more from Circuit Specialists via the Internet, they'll give you a CSI Techmeter DMM — worth $29.00 — for free! (To get this promo, you must enter the code "DMM FREE" — If you have a Jun. 01 issue handy, check out their ad on page 92. You can read the fine print about the offer there.)

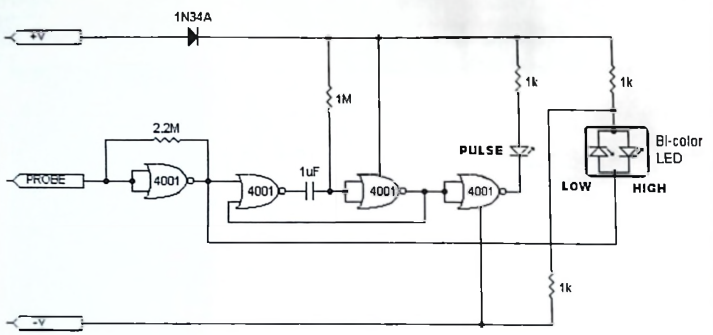
If you follow the buying suggestions outlined here, you will easily earn that free DMM and still stay within your $50.00 budget.

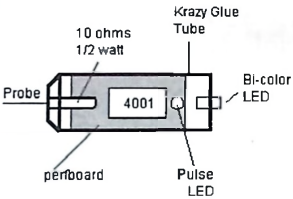
Getting Juiced

That's because you'll need a power supply for your projects — which you can build yourself. For most experiments, you'll need three voltage sources. First, is a five-volt source for logic ICs and microcontrollers. Next, is a variable voltage source to power op-amps, A/D converters, and audio



This power supply can deliver up to one amp total, and can be built for about $25.00.





This reverse-voltage-protected logic probe indicates the state of a logic line or IC pin.

chips, among other devices. Finally, there's a 12.6-volt voltage source that's needed for programming a PIC chip. The following circuit will fill the bill.

It will provide up to one amp of total current at the five-volt and 0-15-volt outputs; e.g., 500 mA from each. The 12.6-volt output can serve up 100 mA of current.

Notice that each voltage regulator has a 0.33uF capacitor on its input pin.

This cap should not be ignored, it improves the regulator's response time, and has to be placed as close as possible to its associated IC. Cost is about $25.00 with a decent cabinet and binding posts.

A Logical Choice

Next, a logic probe would be handy. This device tells you the state of a logic line or IC pin. It indicates whether the line is high or low — or if the signal is a pulse train. That is, the logic is alternating between high and low. The last

PARTS LISTS

Power Supply

Semiconductors
7805 – Five-volt regulator
LM317 – Adjustable voltage regulator
78L12 – 12-volt regulator
1A, 50V Bridge rectifier
1N4001 Diode

Resistors
240 ohms, 1/4W
2.5k Potentiometer

Capacitors
1 – 2200uF, 50V electrolytic
3 – 0.33uF mylar
3 – 1uF tantalum

Misc.
1 – 18VCT, 1A power transformer
1 – SPST toggle switch
1 – 1A fuse
1 – 0-15VDC panel meter (RadioShack 22-410)
1 – Cabinet
4 – Nylon banana jack binding posts

Logic Probe

Semiconductors
1 – 4001 NOR gate
1 – Green LED (Pulse)
1 – Bi-color LED (RadioShack 276-012)
1 – 1N34A germanium diode

Resistors
3 – 1k
1 – 1Meg
1 – 2.2Meg
1 – 10 ohms, 1/2 watt (see text)

Capacitors
1 – 1uF tantalum

Misc.
Krazy Glue tube
Perfboard

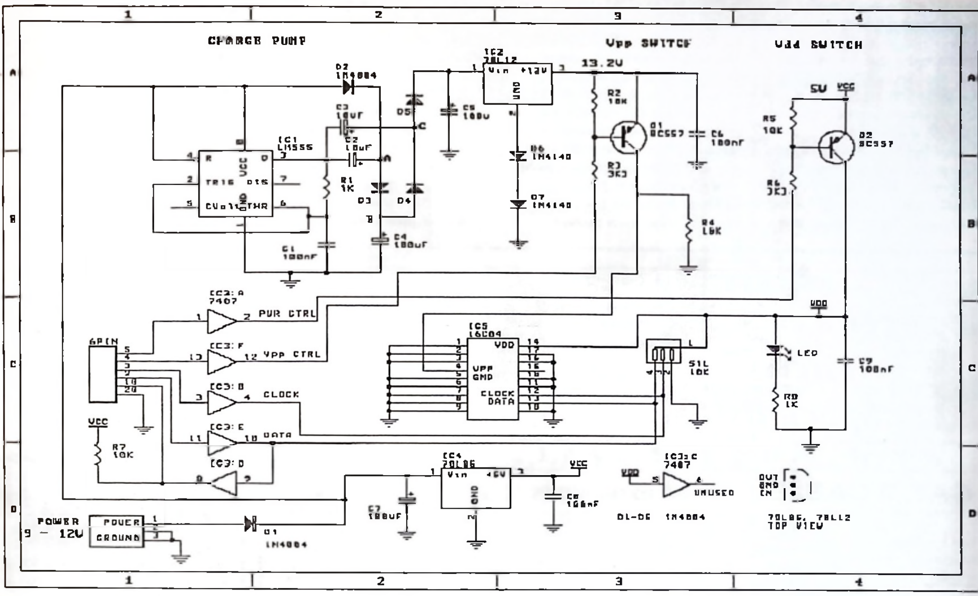
NOPPP Programmer

Semiconductors
1 – 2N3904 transistor
2 – 1N34A diode
1 – 16F84 PIC microcontroller

Resistors
3 – 4.7k
3 – 1k
1 – 2.2k
1 – 330 ohms

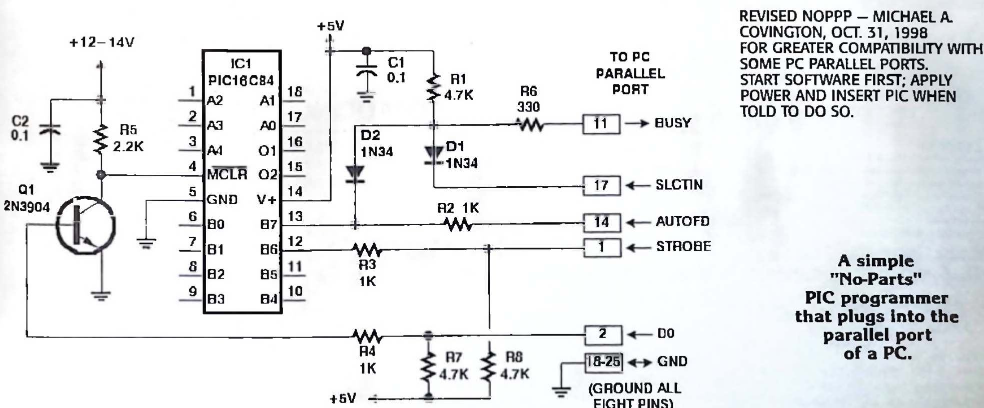
Capacitors
2 – 0.1uF mylar

Misc.
1 – 25-pin D-sub connector
1 – 18-pin IC socket (non-retention contacts)



A version of the "No-Parts" PIC programmer in kit form from Ramsey Electronics (800-446-2295; http://www.ramseyelectronics.com).

PICPRO Pic Chip Programmer



A simple "No-Parts" PIC programmer that plugs into the parallel port of a PC.

feature is especially handy when you can't determine if the signal line is hung up in limbo or changing states faster than the eye can detect. You can buy a logic probe for under $15.00 in kit form, or build it yourself using the schematic shown in this article.

The electronics can be mounted in a discarded Krazy Glue container (the outer housing for the glue tube), with a probe tip (RadioShack 278-705) glued into the tapered tip of the cylinder. The LED is a bi-color red/green indicator, like the RadioShack 276-012. It can be mounted in the red end cap of the glue tube holder. If money is tight, the probe tip can be made from the lead of a 10-ohm, 1/2-watt resistor stuck through a hole drilled in the white end of the tube and glued in place with rubber cement. Not as sturdy as a rigid probe, but it will serve you until more funds become available. The +V and -V leads are made from a pair of mini-alligator jumper cables (RadioShack 278-1156).

PIC Programmer

For PIC projects, you'll need a programming device that, again, you can build yourself. My favorite is NOPPP, the "No-Parts" PIC programmer at www.covingtoninnovations.com/noppp. Just be forewarned that it's not really part-less. It does use about $10.00 of electronic components. The programmer plugs into the parallel port of your PC and programs 16C84, 16F83, and 16F84 PIC chips. For the programmer, you'll want a couple of sturdy IC sockets, because you'll be moving PICs around a lot as you go between programming and testing.

Circuit Specialists sells a similar PIC programmer in kit form (Kit 81; http://store.yahoo.com/webtronics/intopicprog1.html), which includes all the hardware and software you need to get you started with PICs, for $24.95. Be sure to add an extra 16F84 to your order, in case you decide to put one of your inventions to practical use.

You'll also want a datasheet (www.microchip.com) that shows you how to wire and set up your PIC — and a book that teaches you how to program it. A good book for the newbie is *Easy Pic'N: A Beginner's Guide to Using Pic16/17 Microcontrollers from Square 1* by David Benson (www.sq-1.com). Advanced PIC programming is covered in *Design with PIC Microcontrollers*, by John B. Peatman, published by Prentice-Hall. Intermediate between these is *Programming and Customizing the PIC Microcontroller* by Myke Predko.

If you're into the BASIC Stamp, don't pass up *The Nuts & Volts of BASIC Stamps* — a two-volume collection of 75 articles written by Scott Edwards, Jon Williams, and Lon Glazner (www.nutsvolts.com/Store_Pages/Books/Basic_Stamp.htm) and check out the www.geocities.com/SiliconValley/Cable/7772/ web site.

The Final Touches

According to my calculator, the total comes to $36.20 give or take a dollar, DMM and books not included. Oh, don't forget the soldering iron, solder, and hand tools. You'll also need electronic parts, like resistors and capacitors which you can buy from Jameco (800-831-4242; www.jameco.com) for as little as $4.95 per grab bag. A solderless breadboard is also a good investment; prices start at just $5.94.

There you have it. Getting into a fun and exciting — and cutting-edge — hobby for less than $50.00. Now, if I could put the same budget restraints on my girlfriend's shoe collection, I could afford a new car. **NV**

DEALER DIRECTORY

The dealers listed below carry the latest issue of Nuts & Volts, for your convenience.

ALABAMA
Little Professor Book Center
2717 S. 18th St.
Birmingham 35209

ARIZONA
Elliott Electronic Supply
1251 S. Tyndall Ave.
Tucson 85713
Tower Records
3 E. 9th St.
Tempe 85281

AUSTRALIA
DonTronics
P.O. Box 595
29 Ellesmere Cres.
Tullamarine 3043
www.dontronics.com

CALIFORNIA
Abletronics
9155 Archibald Ave. Unit E
Cucamonga 91730
All Electronics
905 S. Vermont Ave.
Los Angeles 90006

14928 Oxnard St.
Van Nuys 91411
Alltronics
2300-D Zanker Rd.
San Jose 95131
Centerfold International
716 N. Fairfax Ave.
Los Angeles 90046
Del Amo Books & News
3758 Sepulveda Blvd.
Torrance 90505
Electro Mavin
2985 E. Harcourt St.
Rancho Dominguez 90221
HSC Electronic Supply
4837 Amber Ln.
Sacramento 95841

3500 Ryder St.
Santa Clara 95051

5681 Redwood Dr.
Rohnert Park 94928
JK Electronics
6395 Westminster Ave.
Westminster 92683
Lion Electronic Labs
4948 E. Townsend Ave.
Fresno 93727
Mar Vac Electronics
2001 Harbor Blvd.
Costa Mesa 92627

12453 Washington Blvd.
Los Angeles 90066

4747 Holt Blvd.
Montclair 91763

2000 Outlet Center Dr.
Ste. 150
Oxnard 93030

1759 Colorado Blvd.
Pasadena 91106

2537 Del Paso Blvd.
Sacramento 95815

5184 Hollister Blvd.
Santa Barbara 93111
OPAMP Technical Books
1033 N Sycamore Ave
Los Angeles 90038
Roger's System Specialists
24895 Ave Rockefeller
Valencia 91355
Sav-On Electronics
13225 Harbor Blvd.
Garden Grove 92643
The Red Barn
Hwy. 299
Bieber 96009
Tower Books
211 Main St.
Chico 95928

7840 Macy Plaza Dr.
Citrus Heights 95610

1280 E. Willow Pass Rd.
Concord 94520

630 San Antonio Rd.
Mountain View 94040

1600 Broadway
Sacramento 95818

2538 Watt Ave.
Sacramento 95821
Tower Records/Video
220 N. Beach Blvd.
Anaheim 92801

6694 Amador Plaza Rd.
Dublin 94568

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Emeryville 94608

4118 Fremont Hub
Fremont 9453

5611 Blackstone
Fresno 93710

23541 Calle De La Louisa
Laguna Hills 9265

6310 E. Pacific Coast Hwy.
Long Beach 90803

2331 S Atlantic Blvd.
Monterey Park 91754

2525 Jones St.
San Francisco 94133

871 Blossom Hill Rd.
San Jose 95123
Video Electronics
3829 University Ave.
San Diego 92105

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Cody Books Ltd.
810 Quayside Dr #222
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V3M 6B9
Com-West Radio Systems Ltd.
8171 Main St.
Vancouver, BC V5X 3L2
Emma Marion Ltd.
2677 E. Hastings St.
Vancouver, BC V5K 1Z5
Muir Communications Ltd.
3214 Douglas St.
Victoria, BC V8Z 3K6

COLORADO
Centennial Electronics, Inc.
2324 E. Bijou
Colorado Springs 80909
Tower Records/Video
2500 E. 1st Ave.
Denver 80206

CONNECTICUT
Archway News
64 Bank St.
New Milford 06776
Tower Records
1145 High Ridge Rd.
Stamford 06905

DELAWARE
Newark Newsstand
70 E. Main St.
Newark 19711

DISTRICT OF COLUMBIA
Tower Records
2000 Pennsylvania Ave.
Washington 20006

FLORIDA
Alfa Electronic Supply
6444 Pembroke Rd.
Miramar 33023
Astro Too
6949 W. Nasa Blvd.
West Melbourne 32904
Clarks Out of Town News
303 S. Andrews Ave.
Fort Lauderdale 33301
Mike's Electronic Distributing Co.
1001 N.W. 52nd St.
Fort Lauderdale 33309
Sunny's At Sunset, Inc.
8260 Sunset Strip
Sunrise 33322

HAWAII
SolarWorks!
525 Lotus Blossom Ln.
Ocean View 96737
Tower Records
4211 Waialae Ave.
Honolulu 96816

611 Keeaumoku
Honolulu 96814

IDAHO
Current Source
451 N. Philippi St.
Boise 83706

ILLINOIS
Tower Records/Video/Books
383 W. Army Trail Rd.
Bloomingdale 60108

2301 N. Clark St. #200
Chicago 60614

1209 E. Golf Rd.
Schaumburg 60173

INDIANA
Surplus Bargain Center
2611 W.Michigan St.
Indianapolis 46222

KANSAS
Hollywood At Home
9063 Metcalf Ave.
Overland Park 66212

LOUISIANA
Lakeside News
3323 Severn Ave.
Metairie 70002

MARYLAND
Tower Records/Video
2566 Solomons Island Rd.
Annapolis 21401

1601 Rockville Pike #210
Rockville 20852

MASSACHUSETTS
Tower Records/Video
1011 Middlesex Turnpike
Burlington 01803

MICHIGAN
Anything Goes
5108 Rochester Rd.
Troy 48098
Little Professors Book Center
22174 Michigan Ave.
Dearborn 48124
Purchase Radio Supply, Inc.
327 E. Hoover Ave.
Ann Arbor 48104
Spectrum Electronics, Inc.
1226 Bridge St. NW
Grand Rapids 49504

MINNESOTA
Radio City, Inc.
2633 County Road 1
Mounds View 55112

MISSOURI
Electronics Exchange
8644 St. Charles Rock Rd.
St. Louis 63114

NEVADA
Amateur Electronic Supply
4640 Polaris
Las Vegas 89103
House of Drake
3129 S. Carson St.
Carson City 89701
Radio World
1656 Nevada Hwy.
Boulder City 89005
Sandy's Electronic Parts
961 Matley Ln #100
Reno 89502
Tower Records/Video
4580 W. Sahara Ave.
Las Vegas 89102

6450 S. Virginia
Reno 89511

NEW JERSEY
H.E.S. Electronics
1715 Route 88
Brick 08724

Tower Records/Video
809 RT 17 S
Paramus 07652

NEW YORK
Ham Central
3 Neptune Rd.
Poughkeepsie 12601
Hirsch Sales Corporation
219 California Dr.
Williamsville 14221
Tower Records/Video
105 Old Country Rd.
Carle Place 11514

350-370 Route 110
Huntington 11746

1961 Broadway
New York 10023

383 Lafayette St.
New York 10003

OHIO
Footsteps
4925 Jackman Rd. Store #58
Toledo 43613
Hosfelt Electronics, Inc.
2700 Sunset Blvd.
Steubenville 43952
Keyways, Inc.
204 S. 3rd St.
Miamisburg 45342

OKLAHOMA
Taylor News & Books
133 W. Main, Ste. 102
Oklahoma City 73102

OREGON
News & Smokes
1060 S.E. M St.
Grants Pass 97526
Norvac Electronics
7940 S.W. Nimbus Ave. Bldg. 8
Beaverton 97005

960 Conger
Eugene 97402

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Salem 97303
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1307 N.E. 102nd Ave.
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425 South St.
Philadelphia 19147
Tower Records
340 W. Dekalb Pike
King of Prussia 19406
Tower Records
Land Title Bldg.
100 S. Broad St.
Philadelphia 19110

TENNESSEE
Tower Books
2404 W. End Ave.
Nashville 37203
Tower Records
504 Opry Mills Dr.
Nashville 37214

TEXAS
BDL News, Inc.
809 Pierce
Houston 77002
Electronic Parts Outlet
3753-B Fondren Rd.
Houston 77063
Mouser Electronics
958 N. Main St.
Mansfield 76063
Tanner Electronics
1301 W. Beltline #105
Carrollton 75006
Tower Records
2403 Guadalupe St.
Austin 78705

VIRGINIA
Tower Records/Video
6200 Little River Turnpike
Alexandria 22312

4110 W. Ox Rd. #12124
Fairfax 22033

1601 Willow Lawn Dr.
Richmond 23230

8389 E. Leesburg Pike
Vienna 22182

WASHINGTON
A-B-C Communications, Inc.
17541 15th Ave. N.E.
Seattle 98155
Supertronix
16550 W. Valley Hwy.
Seattle 98188
Tower Books
10635 N.E. 8th St.
Bellevue 98004

20 Mercer St.
Seattle 98109

WISCONSIN
Amateur Electronic Supply, Inc.
5710 W. Good Hope Rd.
Milwaukee 53223

WYOMING
Western Test Systems
2701 Westland Ct. #B
Cheyenne 82001

OP-AMP COOKBOOK

by Ray Marston

Part 3 • Oscillators and Switching Circuits

Ray Marston looks at practical op-amp oscillators and switching circuits in the third episode of this four-part survey of op-amp principles and applications.

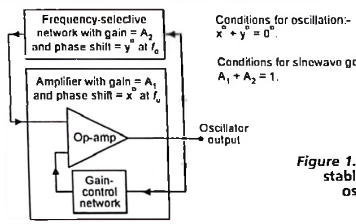


Figure 1. **Conditions for stable sinewave oscillation.**

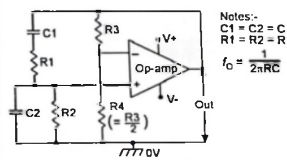


Figure 2. **Basic Wien Bridge sinewave oscillator.**

The opening episode of this 'op-amp' series described the basic operating principles of conventional voltage-differencing op-amps (typified by the 741 type), and showed some basic circuit configurations in which they can be used. The present episode looks at practical ways of using such op-amps in various oscillator and switching applications.

When reading this installment, note that most practical circuits are shown designed around a standard 741 or 3140-type op-amp and operated from dual 9V supplies, but that these circuits will usually work (without modification) with most voltage-differencing op-amps, and from any DC supply within that op-amp's operating range.

SINEWAVE OSCILLATORS

An op-amp can be made to act as a sinewave oscillator by connecting it as a linear amplifier in the basic configuration shown in *Figure 1*, in which the amplifier output is fed back to the input via a frequency-selective network, and the overall gain of the amplifier is controlled via a level-sensing system.

For optimum sinewave generation, the feedback network must provide an overall phase shift of zero degrees and a gain of unity at the desired frequency. If the overall gain is less than unity, the circuit will not oscillate and, if it is greater than unity, the output waveform will be distorted.

One way of implementing the above principle is to connect a Wien Bridge network and an op-amp in the basic configuration shown in *Figure 2*. Here, the frequency-sensitive Wien Bridge network is constructed from R1-C1 and R2-C2. Normally, the network is symmetrical, so that C1 = C2 = C, and R1 = R2 = R. The main feature of the Wien network is that the phase relationship of its output-to-input signals varies from -90° to +90°, and is precisely 0° at a center frequency (f_O) of $1/2\pi CR$. At this center frequency, the symmetrical network has a voltage gain of 0.33.

Thus, in *Figure 2*, the Wien network is connected between the output and the non-inverting input of the op-amp, so that the circuit gives zero overall phase shift at f_O, and the actual amplifier is given a volt-

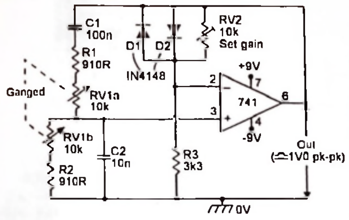


Figure 5. **Diode-regulated 150Hz-1.5kHz Wien Bridge oscillator.**

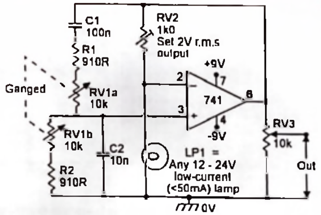


Figure 4. **150Hz-1.5kHz lamp-stabilized Wien Bridge oscillator.**

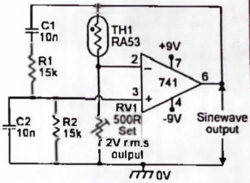


Figure 3. **Thermistor stabilized 1kHz Wien Bridge oscillator.**

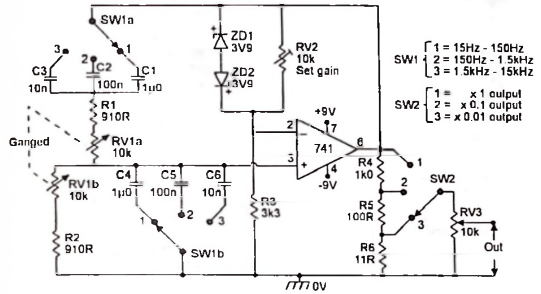


Figure 7. **Three-decade (15Hz-15kHz) Wien Bridge oscillator.**

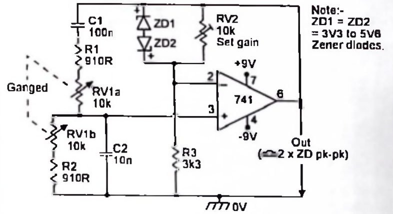


Figure 6. **Zener-regulated 150Hz-1.5kHz Wien Bridge oscillator.**

age gain of x3 via feedback network R3-R4, to give the total system an overall gain of unity.

The circuit thus provides the basic requirements of sinewave oscillation. In practice, however, the ratios of R3-R4 must be carefully adjusted to give overall voltage gain of precise unity that is necessary for low-distortion sinewave generation.

The basic *Figure 2* circuit can easily be modified to give automatic gain adjustment and amplitude stability by replacing the passive R3-R4 gain-determining network with an active gain-control network that is sensitive to the amplitude of the output signal, so that gain decreases as the mean output amplitude increases, and vice versa. *Figures 3* to *7* show some practical versions of Wien Bridge oscillators with automatic amplitude stabilization.

THERMISTOR-STABILIZED CIRCUITS

Figure 3 shows the basic circuit of a 1kHz thermistor-stabilized Wien bridge oscillator of the type that has been popular in the UK and other European countries for many years. The thermistor used here is a rather expensive and delicate RA53 (or similar) negative-temperature-coefficient (ntc) type. The thermistor (TH1) and RV1 form a gain-determining network.

The thermistor is heated by the mean output power of the op-amp, and at the desired output signal level has a resistance value double that of RV1, thus giving the op-amp a gain of x3 and the overall circuit a gain of unity. If the oscillator output starts to rise, TH1 heats up and reduces its resistance, thereby automatically reducing the circuit's gain and stabilizing the amplitude of the output signal.

An alternative method of thermistor stabilization is shown in *Figure 4*; this circuit variant is very popular in the USA. In this circuit, a low-current filament lamp is used as a positive-temperature-coefficient (ptc) thermistor, and is placed in the

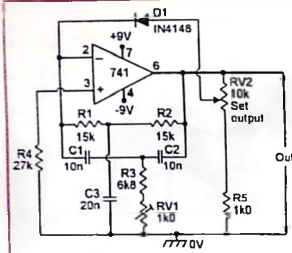


Figure 8. **Diode-regulated 1kHz Twin-T oscillator.**

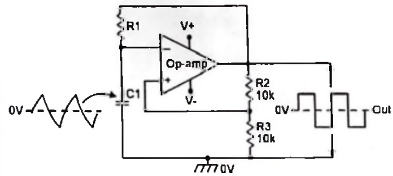


Figure 9. **Basic relaxation oscillator circuit.**

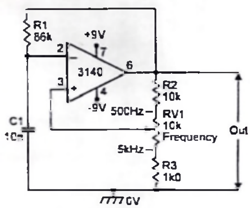


Figure 10. **Simple 500Hz-5kHz squarewave generator.**

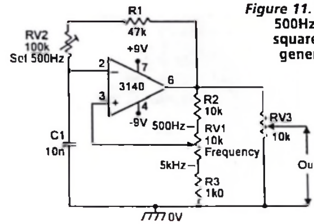


Figure 11. **Improved 500Hz-5kHz squarewave generator.**

lower part of the gain-determining feedback network.

Thus, if the output amplitude increases, the lamp heats up and increases its resistance, thereby reducing the circuit gain and providing automatic amplitude stabilization. This circuit also shows how the Wien network can be modified by using a twin-gang pot to make the oscillator frequency variable over the range 150Hz to 1.5kHz, and how the sinewave output amplitude can be made variable via RV3.

Note in the *Figure 3* and *4* circuits that the pre-set pot should be adjusted to set the maximum mean output signal level to about 2V RMS, and that under this condition, the sinewave has a typical total harmonic distortion (THD) level of about 0.1%.

If the circuit's thermistor is a low-resistance type, it may be necessary to interpose a bidirectional current-booster stage between the op-amp output and the input of the amplitude control network, to give it adequate drive.

Finally, a slightly annoying feature of thermistor-stabilized circuits is that, in variable-frequency applications, the sinewave's output amplitude tends to judder or 'bounce' as the frequency control pot is swept up and down its range.

DIODE-STABILIZATION CIRCUITS

The amplitude 'bounce' problem of variable-frequency circuits can be minimized by using the basic circuits in *Figures 5* or *6*, which rely on the onset of diode or zener conduction for automatic gain control. In essence, RV2 is set so that the circuit gain is slightly greater than unity when the output is close to zero, causing the circuit to oscillate, but as each half-cycle nears the desired peak value, one or other of the diodes starts to conduct and thus reduces the circuit gain, automatically stabilizing the peak amplitude of the output signal.

This 'limiting' technique typically results in the generation of 1% to 2% THD on the sinewave output when RV2 is set so that oscillation is maintained over the whole frequency band. The maximum peak-to-peak output of each circuit is roughly double the breakdown voltage of its diode regulator element. In the *Figure 5* circuit, the diodes start to conduct at 500mV, so the circuit gives a peak-to-peak output of about 1V0; in the *Figure 6* circuit, the zener diodes are connected back-to-back and may have values as high as 5V6, giving a pk-to-pk output of about 12V.

The frequency ranges of the above circuits can be altered by changing the C1 and C2 values; increasing the values by a decade reduces the frequency by a decade. *Figure 7* shows the circuit of a variable-frequency Wien oscillator that covers the range 15Hz to 15kHz in three switched decade ranges. The circuit uses zener diode amplitude stabilization; its output amplitude is variable via both switched and fully-variable attenuators. Note that the maximum useful operating frequency of this type of circuit is restricted by the slew-rate limitations of the op-amp. The limit is about 25kHz with a 741 op-amp, or about 70kHz with a CA3140.

A TWIN-T OSCILLATOR

Another way of making a sinewave oscillator is to wire a Twin-T network between the output and input of an inverting op-amp, as shown in the diode-regulated 1kHz oscillator circuit in *Figure 8*. The Twin-T network comprises R1-R2-R3-RV1 and C1-C2-C3, and in a 'balanced' circuit; these components

are in the ratios R1 = R2 = 2 (R3 + RV1), and C1 = C2 = C3/2.

When the network is perfectly balanced, it acts as a frequency-dependent attenuator that gives zero output at a center frequency (f_O) of 1/2 π R1.C1, and a finite output at all other frequencies. When the network is imperfectly balanced, it gives a minimal but finite output at f_O, and the phase of this output depends on the direction of the imbalance: if the imbalance is caused by (R3 + RV1) being too low in value, the output phase is inverted relative to the input.

In *Figure 8*, the 1kHz Twin-T network is wired between the output and the inverting input of the op-amp, and RV1 is critically adjusted so that the Twin-T gives a small inverted output at f_O; under this condition zero overall phase inversion occurs around the feedback loop, and the circuit oscillates at the 1kHz center frequency.

In practice, RV1 is adjusted so that oscillation is barely sustained and, under this condition, the sinewave output distortion is less than 1% THD. Automatic amplitude control is provided via D1, which provides a feedback signal via RV2; this diode progressively conducts and reduces the circuit gain when the diode forward voltage exceeds 500mV.

To set up the *Figure 8* circuit, first set RV2 slider to the op-amp output and adjust RV1 so that oscillation is just sustained; under this condition, the output signal has an amplitude of about 500mV pk-to-pk. RV2 then enables the output signal to be varied between 170mV and 3V0 RMS. Note that Twin-T circuits make good fixed-frequency sinewave oscillators, but are not suitable for variable-frequency use, due to the difficulties of varying three or four network components simultaneously.

SQUAREWAVE GENERATORS

Figure 9 shows a basic op-amp relaxation oscillator or squarewave generator using dual (split) power supplies. Its circuit action is such that C1 alternately charges and discharges (via R1) towards an 'aiming' or reference voltage set by R2-R3, and each time C1 reaches this aiming voltage, a regenerative comparator action occurs and makes the op-amp output switch state (to positive or negative saturation); this action produces a symmetrical squarewave at the op-amp's output and a non-linear trianglewave across C1.

The operating frequency can be varied by altering either the R1 or C1 values or the R2-R3 ratios; this circuit is thus quite versatile. A fast op-amp such as the CA3140 should be used if good output rise and fall times are needed from the squarewave.

Figure 10 shows the basic circuit adapted to make a practical 500Hz to 5kHz squarewave generator, with frequency variation obtained by altering the R2-RV1-R3 attenuator ratio. *Figure 11* shows the circuit improved by using RV2 to pre-set the range of the RV1 frequency con-

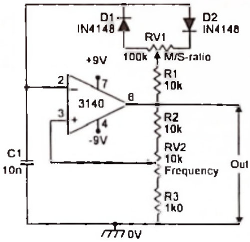


***Figure 13.* Squarewave generator with variable M/S-ratio and frequency.**

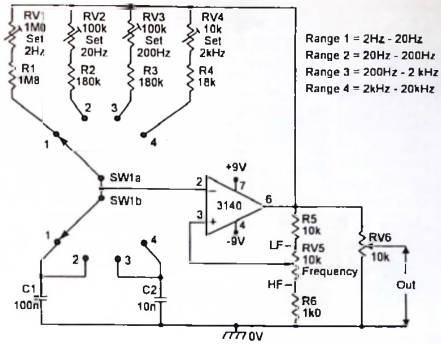


***Figure 12.* Four-decade, 2Hz-20kHz, squarewave generator.**

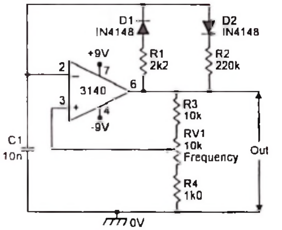


***Figure 14.* Variable-frequency narrow-pulse generator.**

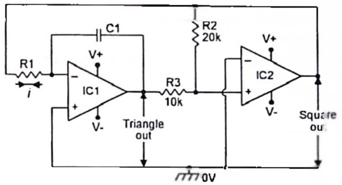


***Figure 15.* Basic triangle/square function generator.**

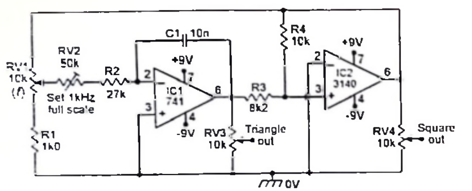


Figure 16. **100Hz-1kHz triangle/square function generator.**

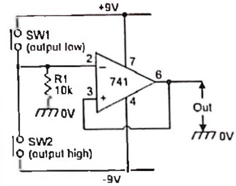


Figure 18. **Simple manually-triggered bistable.**

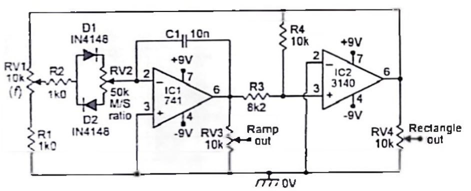


Figure 17. **100Hz-1kHz ramp/rectangle generator with variable slope-M/S ratio.**

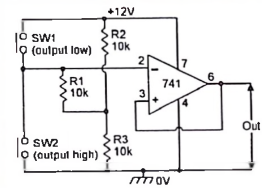
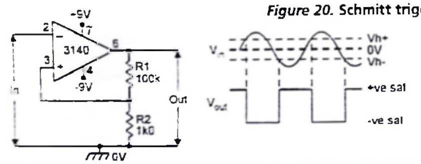


Figure 19. **Single-supply manually-triggered bistable.**

Figure 20. **Schmitt trigger.**



trol, and by using RV3 as an output amplitude control.

Figure 12 shows how the above circuit can be modified to make a general-purpose squarewave generator that covers the 2Hz to 20kHz range in four switched decade ranges. Pre-set pots RV1 to RV4 are used to precisely set the minimum frequency of the 2Hz to 20Hz, 20Hz to 200Hz, 20Hz to 2kHz, and 2kHz to 20kHz ranges, respectively.

VARIABLE SYMMETRY

In the basic *Figure 9* circuit, C1 alternately charges and discharges via R1, and the circuit generates a symmetrical squarewave output. The circuit can easily be modified to give a variable-symmetry output by providing C1 with alternate charge and discharge paths, as shown in *Figures 13* and *14*.

In the *Figure 13* circuit, the mark/space (M/S) ratio of the output waveform is fully variable from 11:1 to 1:11 via RV1, and the frequency is variable from 650Hz to 6.5kHz via RV2. The circuit action is such that C1 alternately charges up via R1-D1 and the left-hand side of RV1, and discharges via R1-D2 and the right-hand side of RV1, to provide a variable-symmetry output. In practice, variation of RV1 has negligible effect on the operating frequency of the circuit.

In the *Figure 14* circuit, the mark period is determined by C1-D1-R1, and the space period by C1-D2-R2; these periods differ by a factor of 100, so the circuit generates a narrow pulse waveform. The pulse frequency is variable from 300Hz to 3kHz via RV1.

TRIANGLE-SQUARE GENERATION

Figure 15 shows the basic circuit of a function generator that simultaneously generates a linear triangle and a square waveform, using two op-amps. IC1 is wired as an integrator, driven from the output of IC2, and IC2 is wired as a differential voltage comparator, driven from the output of IC1 via potential divider R2-R3, which is connected between the outputs of IC1 and IC2. The squarewave output of IC2 switches alternately between positive and negative saturation. The circuit functions as follows.

Suppose initially that the output of IC1 is positive and the output of IC2 has just switched to positive saturation. The inverting input of IC1 is a virtual earth point, so a current (i) of $+V_{sat}/R1$ flows into R1, causing the output of IC1 to start to swing down linearly at a rate of i/C1 volts per second. This output is fed — via the R2-R3 divider — to the non-inverting input of IC2, which has its inverting terminal referenced directly to ground.

Consequently, the output of IC1 swings linearly to a negative value until the R2-R3 junction voltage falls to zero, at which point IC2 enters a regenerative switching phase, in which its output abruptly switches to negative saturation. This reverses the inputs of IC1 and IC2, so IC1 output starts to rise linearly, until it

reaches a positive value at which the R2-R3 junction voltage reaches the zero volts reference value, initiating another switching action. The whole process then repeats add infinitum.

Important points to note about the *Figure 15* circuit are that the pk-to-pk amplitude of the linear triangle waveform is controlled by the R2-R3 ratio, and that the circuit's operating frequency can be altered by changing either the ratios of R2-R3, the values of R1 or C1, or by feeding R1 from a potential divider connected to the output of IC2 (rather than directly from IC2 output. *Figure 16* shows the practical circuit of a variable-frequency triangle/square generator that uses the latter technique.

In *Figure 16*, the input current of C1 (obtained from RV2-R2) can be varied over a 10:1 range via RV1, enabling the frequency to be varied from 100Hz to 1kHz; RV2 enables the full-scale frequency to be set to precisely 1kHz. The amplitude of the linear triangle output waveform is fully variable via RV3, and of the squarewave via RV4.

The *Figure 16* circuit generates symmetrical output waveforms, since C1 alternately charges and discharges at equal current values (determined by RV2-R2, etc.). *Figure 17* shows how the circuit can be modified to make a variable-symmetry ramp/rectangle generator, in which the slope is variable via RV2. C1 alternately charges via R2-D1 and the upper half of RV2, and discharges via R2-D2 and the lower half of RV2.

SWITCHING CIRCUITS

To conclude this month's edition of the 'OP-AMP COOKBOOK,' *Figures 18* to *20* show three ways of using op-amps as simple regenerative switches. *Figure 18* shows the connections for making a simple manually-triggered bistable circuit. Note here that the inverting terminal of the op-amp is tied to ground via R1, and the non-inverting terminal is tied directly to the output. The circuit operates as follows.

Normally, SW1 and SW2 are open. If SW1 is briefly closed, the op-amp inverting terminal is momentarily pulled high and the output is driven to negative saturation; consequently, when SW1 is released again, the inverting terminal returns to zero volts, but the output and the non-inverting terminals remain in negative saturation.

The output remains in this state until SW2 is briefly closed, at which point, the op-amp output switches to positive saturation, and locks into this state until SW1 is again operated. The circuit thus gives a bistable form of operation. *Figure 19* shows how the circuit can be modified for operation from a single-ended power supply. In this case, the op-amp's inverting terminal is biased to half-supply volts via R1 and the R2-R3 potential divider.

Finally, *Figure 20* shows how to connect an op-amp as a Schmitt trigger, which can (for example), be used to convert a sinewave input into a squarewave output. The circuit operates as follows.

Suppose initially that the op-amp output is at a positive saturation value of 8V0. Under this condition, the R1-R2 divider feeds a positive reference voltage of 8V x (R1+R2)/R2 (= about 80mV in this case) to the op-amp's non-inverting pin. Consequently, the output remains in this state until the input rises to a value equal to this voltage, at which point the op-amp output switches regeneratively to a negative saturation level of -8V0, feeding a reference voltage of -80mV to the non-inverting input.

The output remains in this state until the input signal falls to -80mV, at which point, the op-amp output switches regeneratively back to the positive saturation level. The process then repeats add infinitum. The actual switching levels can be altered by changing the R1 value. **NV**

Next month, Ray looks at practical op-amp instrumentation and test-gear circuits in the final installment of this four-part series.

Circle #123 on the Reader Service Card.

Circle #110 on the Reader Service Card.

The PhoneTester

Test Your Telephones, Lines, and Accessories

You get up this morning and your telephones don't work. Do you call the phone company to report that your phones are out and wait for their service?

by Bill Stiles

If you are paying a monthly fee for "in-house" wiring service, you may. (If your phone company offers two levels of "in-house" service, and you chose the lower level, you may have to pay a service charge if the trouble is in a telephone or accessory, not in the wiring.) If (like me) you felt the cost of in-house service is too much, and chose not to use their in-house service, you need to determine if the problem is your responsibility or the phone company's.

Outside your house, there is usually a telephone interface box. In an apartment, it may be in a basement or a service area. A hinged cover over part of the box, held closed by one or two screws, is marked "customer access." Inside this cover is a standard RJ-11 modular telephone jack, a modular plug on a short wire, and screw terminals where the wires going into your house are connected. Everything before this box is the phone company's responsibility. Everything from this box to your phone is your responsibility. The jack is connected to the phone line, the plug wire is connected to the screw terminals.

The first test is to unplug the wire from the jack, and connect a "known-good" telephone to.the jack. If the phone works, the problem is in your phone wiring, or a shorted telephone or accessory. If the phone doesn't work, you might want to try another phone before calling the phone company.

Better yet, use the PhoneTester to measure the voltage and current, and compare these values to those measured earlier when the phones were working, or with the normal values on a phone line. The PhoneTester is also used for finding the trouble in your wiring, telephones, and accessories.

Telephone Systems

Before we describe the PhoneTester, we will describe some of the voltages and signals seen on the phone line. Some details seem to be not well known. I'm not an expert, but I believe the following description is correct.

The two-wire telephone line carries several signals, both voice (or data) and control. For audio, the line is a balanced line, impedance is about 600 ohms, with a signal level similar to that of a low-impedance "line-level" line in pro audio. Since this is a balanced line, nothing should be connected to it which has any path to ground, even at a high impedance. Also, the power supply of anything connected to the phone line must be well-insulated.

In addition to the primary voice or data signal, there are others in the audio range: the "ring-back" signal to tell the caller the other phone is ringing, the dial tone, the busy signal, and the audio tones used for tone dialing.

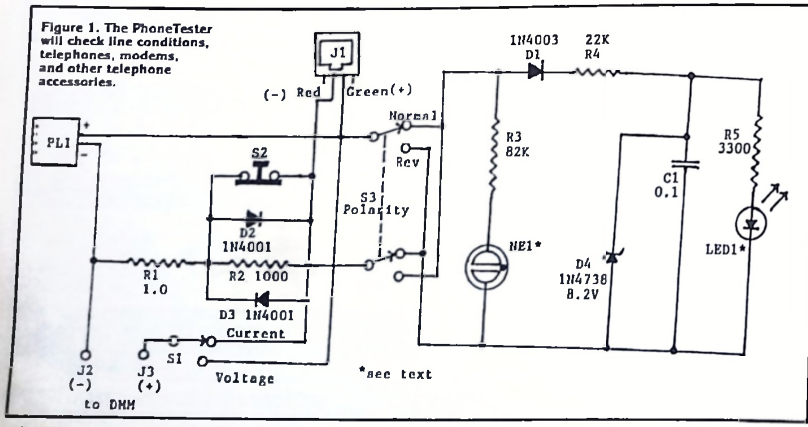
The line also carries a DC voltage between the wires, used both for signaling and to power the telephone. The nominal value for this is 48 VDC, with an effective series resistance at the phone company's central office of about 1,500 ohms. (Both the voltage and resistance may be a little higher. My home phone line consistently measures 51.6 VDC, and the calculated resistance, by measuring the "off-hook" voltage and current, is about 1,590 ohms.)

When a telephone is taken off-hook, the current drawn by the phone (about 25 to 29 mA) drops the voltage to five to nine volts. This drop in voltage signals the switching equipment in the central office that you want to make a call. In pulse dialing, this DC voltage is also pulsed to transmit the numbers dialed to the switching equipment. (In tone dialing, two audio tones, produced when each button is pressed, signal the numbers dialed.)

The other signal on the line is the ringing voltage. The nominal value is 86 VAC at 20 Hz, but the voltage is sometimes a little higher. Anything connected to the line must be able to withstand this voltage.

Because of the DC voltage on the line, any component which has a DC current path and is connected to the line — such as a transformer or mechanical bell ringer — must have a series capacitor to allow only AC to pass. This capacitor should have a working voltage of at least 100 VAC or 250 VDC, because of the ringing voltage. Also, FCC regulations (47 CFR Part 68) require that anything connected to the line should have a DC current draw, when the line is not in use, of not more than that drawn by a five-

Figure 1. The PhoneTester will check line conditions, telephones, modems, and other telephone accessories.



megohm resistor, 10 microamperes at the approximately 50 volts on the line. (Ten megohms, five microamperes, is better.) The PhoneTester allows easy measurement of this current. (For preventive maintenance, the phone company measures the current when the line is not in use, to check for leakage.)

Circuit Description

The PhoneTester allows measurement of the phone line voltage, the leakage current in microamps, and the in-use current in milliamps. The schematic is shown in Figure 1. The input is through a standard RJ-11 modular telephone plug and cable, PL1. The plug which was removed to allow connection of PL1 is connected to output jack J1, to allow measurement of line current. Measurements are made with a digital multimeter (DMM) connected to J2 and J3, or with an optional digital panel meter built into the PhoneTester case.

J2 is connected to the negative side of the input line. When S1 is in the voltage position, J3 is connected to the positive side of the input. When S1 is in the current position, J2 and J3 are connected across one-ohm resistor R1. One milliampere through R1 produces a reading of one millivolt, giving a direct reading of the current in the phone line.

If an auto-ranging DMM is used, changing the DMM range is not necessary when switching between voltage and current measurement. To measure leakage current, normally-closed push-button switch S2 is pressed, placing 1,000-ohm resistor R2 in the circuit. Now, a reading of one millivolt indicates a current of one microampere. If ring voltage is sent over the line while S2 is open, D2 and D3 limit the voltage across R2 and the DMM, and allow the ring voltage to reach J1.

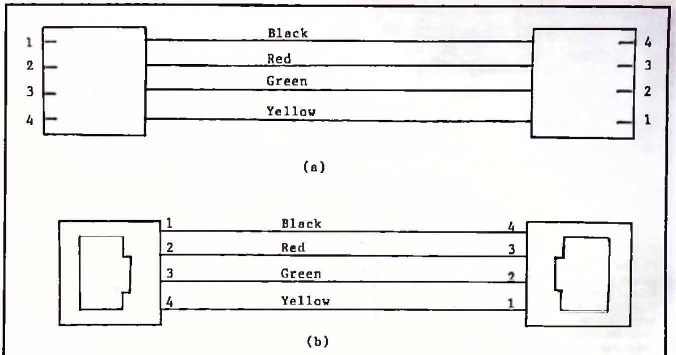


Figure 2. (a) Telephone line cords; (b) Cord couplers.

LED1 and DPDT switch S3 provide a check for line polarity, while NE1 indicates the presence of ring voltage on the line. LED1 should be a low-current LED (2 mA), since the 15 to 20 mA current of a standard LED will send an "off-hook" signal to the phone company. Diode D1 prevents the negative cycles of the ring voltage from reaching LED1, while R4 and zener diode D4 limit the maximum voltage of the positive cycles. C1 bypasses any possible high-frequency noise. R4 and R5 provide the voltage-dropping resistance for LED1. The resistance was split into two resistors to allow use of a higher-voltage zener diode. (Very low-voltage zeners seem to have poorer regulation than those over about five volts.)

Construction

The prototype PhoneTester was built in a plastic project case that measures about 4 by 2.5 by 2.5 inches. The switches, jacks, LED1, and NE1 were mounted on the case. Remaining parts were mounted on a small prototype PC board, cut from a larger board with a fine-tooth hacksaw. The board and the parts mounted on the case were connected with stranded hook-up wire. J1 is a surface-mount

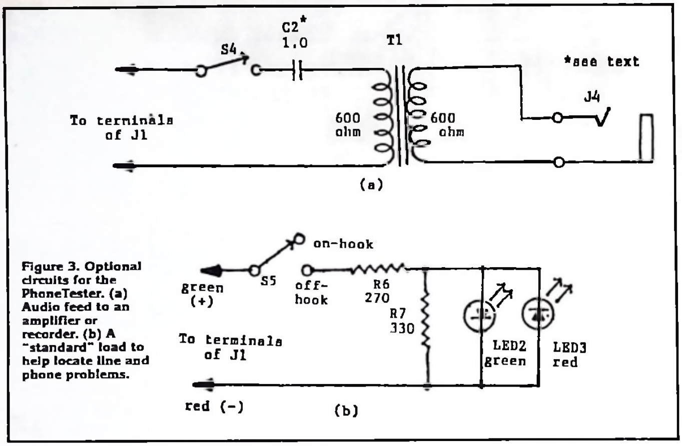


Figure 3. Optional circuits for the PhoneTester. (a) Audio feed to an amplifier or recorder. (b) A "standard" load to help locate line and phone problems.

standard RJ-11 telephone jack, mounted on the outside of the case with connecting wires going through a hole in the case. J2 and J3 and tip jacks — Mouser Electronics stock no. 530-105-0802-1 or similar — will fit the tips of most DMM probes.

Although in standard telephone line cords the red wire is negative and green is positive, I used a black jack for J2 (negative) and a red jack for J3, to match the normal colors of DMM probes. For accuracy, I used 1% resistors for R1 and R2. Some suppliers do not sell 1% resistors in small quantities, however, they are available in single quantities from RadioShack.com (formerly TechAmerica) and Mouser Electronics, and in quantities of 10 (at a very low price) from MCM Electronics. Also, most suppliers do not stock 1% resistors with values below 10 ohms.

For R1, I used a 1% three-watt type RS resistor, Mouser Electronics stock no. 71-RS2B-1.0. An alternative to 1% resistors is to measure several 5% resistors and use the one nearest to the center of the measured values.

LED1 is a low-current (2 mA) LED, RadioShack 276-044 or similar. Unfortunately, the 276-044 and two others, 276-303 and 276-310, are not listed in the *2001 RadioShack* catalog. Checking with a local RadioShack store confirmed that they have been discontinued, although that store still had all three types in stock. Several 2 mA LEDs are listed in the catalog of RadioShack.com and one, part no. 136282, is listed by Jameco Electronics. Several other parts suppliers also carry them, but you may have to search through the LED listings to find them. Super-bright LEDs also will often be bright enough at 2 mA to be used for LED1. Since LED current is determined by the series resistors, it is not necessary to change R4 and R5 when using a different LED.

Ring indicator NE1 is a type NE-2 neon lamp, also called type A1A. High-intensity neon lamps (such as the NE-2H, also called C2A) cannot be used, as their breakdown (firing) voltage (95 VAC) is higher than most ring voltages. (The breakdown voltage of the NE-2 is 65 VAC.) R3 and NE1 can be replaced by some self-contained 120 VAC neon pilot lights, which are easier to install. However, many of these use a high-intensity neon lamp, and there is usually no indication if the lamp used is a high-intensity unit or not, so it must be determined by testing. If you want to substitute another type of neon lamp, breakdown voltages for several types are listed in the catalogs of RadioShack.com and Mouser Electronics. The current rating should be one mA or less.

Unfortunately, the RadioShack catalog no. 272-1100 cannot be used for NE1, even though it is listed in the catalogs for 1999, 2000, and 2001 as Lamp A1A (NE2). The 272-1100 package is marked C2A (NE-2H).

PhoneTester Parts List

D1 - 1N4003 or 1N4004 Silicon diode
D2, D3 - 1N4001 Silicon diode
D4 - 1N4738 Zener diode, 8.2 volts
LED1 - Low-current (2 mA) LED (see text)
R1 - 1.0 ohm, 1% resistor (see text)
R2 - 1,000 ohm, 1% resistor (see text)
R3 - 82K 1/4 watt 5% resistor
R4 - 22K 1/4 watt 5% resistor
R5 - 3.3K 1/4 watt 5% resistor
C1 - 0.1 uF 50-volt ceramic capacitor
S1 - SPDT toggle switch
S2 - SPST push-button switch, normally closed
S3 - DPDT toggle switch
J1 - RJ-11 telephone jack
J2, J3 - tip jack
NE1 - NE2 (A1A) neon lamp (see text)
PL1 - telephone cord with RJ-11 plug (see text)
Misc: Enclosure, wire, etc.

Parts List — Optional Circuits

LED2 - standard (20 mA) LED, green
LED3 - standard (20 mA) LED, red
LED4, LED5 - Low-current (2 mA) LED
R6 - 270 ohm 1/4 watt 5% resistor
R7 - 330 ohm 1/4 watt 5% resistor
R8 - 39K 1/4 watt 5% resistor
R9 - 2K 1% resistor (see text)
R10 - 2 Meg 1% resistor (see text)
C2, C3 - 1.0 uF 250 WVDC capacitor (RadioShack 272-1055 or similar)
T1 - 600 ohm - 600-ohm transformer (RadioShack 273-1374 or similar)
J4 - Mono phone jack (or other connector as desired)
S4, S5, S6 - SPST toggle switch
DPM1 - Digital Panel Meter module (see text)
B1 - Nine-volt battery

The current is listed as three mA and the package is marked "minimum voltage 95 VAC." (Both indicate a high-intensity lamp.) The catalog no. 272-1102 is listed both in the catalogs and on the package as C2A (NE-2H), so it cannot be used. I have not checked the RSU 11338928, but the catalog says it is an A9A (NE-2E), with a current rating of 0.7 mA, which could be used for NE1. Type NE-2 is available from several other suppliers, including RadioShack.com, Jameco Electronics, and Mouser Electronics.

Telephone Cord Polarity

A problem in building telephone accessories is line cord polarity. The wiring of a telephone line cord is shown in Figure 2a. This has sometimes been called "straight-through" wiring (*Telephone Repair Illustrated*, Stephen J. Bigelow, TAB Books (1993), pages 93 and 95), but if the plug terminals are numbered, as in Figure 2a, it is actually cross-wired; terminal 1 of one plug is connected to terminal 4 of the other plug, terminal 2 to 3, 3 to 2, and 4 to 1.

Because of the cross-wiring of cords, a coupler used to connect two cords to make a longer cord, must also by cross-wired (Figure 2b). In most cases, the black and yellow wires are not used. They may be used for the second line in a two-line installation, and the black wire has sometimes been used for ground. When you buy a single-line telephone, the line cord with it often has only the red and green wires. Most replacement cords have all four wires, but there is sometimes a low price on two-wire cords.

As a further complication, there are cords and couplers available, intended for data use

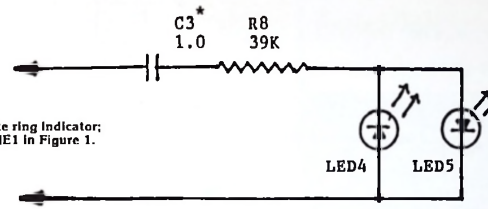


Figure 4. Alternate ring indicator; replaces R3 and NE1 in Figure 1.

(networking/computer sharing), which look like telephone cords, but are straight-wired (1 to 1, 2 to 2, etc.). Both types of cords are listed in the catalogs of Jameco Electronics, Marlin P. Jones & Associates, Hosfelt Electronics, and All Electronics.

I have not found straight-wired data cords listed by any other supplier, and they have been dropped from All Electronics' recent catalog (no. 500), but there are reports of cords being purchased for telephone use which were found to be straight-wired (*Nuts & Volts*, Fred Blechman, Mar. 2000, page 86, bottom of column 1.)

Some circuits for telephone accessories have been published which use jacks for both input and output. Since such a device is actually a coupler with extra circuitry between the input and output jacks, it must also be cross-wired. It is also necessary to check the input cord used with it to make sure it is cross-wired. I prefer a permanently attached input cord and plug for the PhoneTester. It needs to be checked only once, when it is built.

How do you make sure of the polarity of your PL1 input cord? Check it! Telephone cords can be purchased which have a plug on one end and wires on the other. If you have a phone cord crimping tool, RJ-11 plugs, and flat telephone wire, you can make a cord. I usually buy a cord with plugs on both ends and cut it in half. In this case, on one end, the red wire will be negative, and on the other half, it will be positive. In any case, the PhoneTester input cord should be checked to make sure which wire is negative. (For this reason, I did not indicate wire colors on PL1 of the PhoneTester schematic.)

One method for checking polarity of the cord is to use an RJ-11 telephone jack which has color-coded wires or terminals. Connect a DC voltage source to the jack, negative to red and positive to green. Plug the cord being checked into the jack and use a voltmeter to determine which wire of the cord is negative. Another way is to plug the cord into an in-use telephone jack and use a voltmeter to determine the polarity of the output wires of the cord. In this case, it is necessary to make sure the in-use jack has the correct polarity, since you may find reversed polarity in existing phone wiring. This can be done by using a phone line polarity tester such as the RadioShack 43-104, or by removing the cover of the in-use jack and using a voltmeter to make sure the red wire is negative.

After determining which wire from PL1 is negative, it is connected to the junction of R1 and J2. The positive wire is connected to the junction of the green wire from J1 with S1 and S3. You may want to connect the yellow and black wires between PL1 and J1. If the red wire from PL1 is negative, connect yellow to yellow and black to black. If the red wire from PL1 is positive, connect yellow to black and black to yellow. (Most telephones and commercially-sold accessories will work even if the input polarity is reversed. This is done by feeding polarity-sensitive parts of the circuit through a full-wave bridge rectifier, which will have the correct output polarity regardless of the input polarity.)

Testing

First, connect a DMM to measure the resistance between J2 and J3. With S1 in the voltage position, there should be no reading on the highest range. With S1 in the current position, the reading should be one ohm, and with S2 pressed, 1,000 ohms. Next, change the DMM to DC voltage, and plug PL1 into a working telephone jack. (Testing the jack for correct polarity has been described above.) With S1 in the voltage position, the meter should read about 48 to 50 volts. LED1 should light in the normal position of S3, and not light in the reverse position.

With S1 in the current position and S3 in the normal position (LED1 lit), the meter should read about 2 millivolts, indicating a current of about 2 mA through LED1. With S3 in the reverse position, the meter should read zero. Pressing S2 to test for leakage in the PhoneTester should also give a reading of zero. A telephone connected to J1 should work normally.

The easiest way to test ringing indicator NE1 is to have a friend call your number. On some older phone company equipment, if you dial your own number and hang up, your phone will ring. On newer equipment this feature — called ringback — requires a code number which the phone company does not usually want to give out.

Using the PhoneTester

As mentioned, the PhoneTester can be used to check your wiring and equipment by connecting it at the telephone interface box. PL1 of the PhoneTester is connected to the jack in the interface box. The plug in the box is connected to J1 of the PhoneTester. The voltage should be near 50 volts. The leakage current — when the line is not in use — should be a few microamps. (Note that when measuring either current or voltage, S3 should be in the position where LED1 is not lit. The 2 mA current of LED1 will cause a drop of about three volts in the line voltage.) It is a good idea to measure and record these values when the telephones are working properly. My home phone wiring, most of it about 40 years old, has a total not-in-use current of about 10 microamps, with four telephones connected to the wiring. Line-in-use indicators, which light an LED when the line is in use, have a few

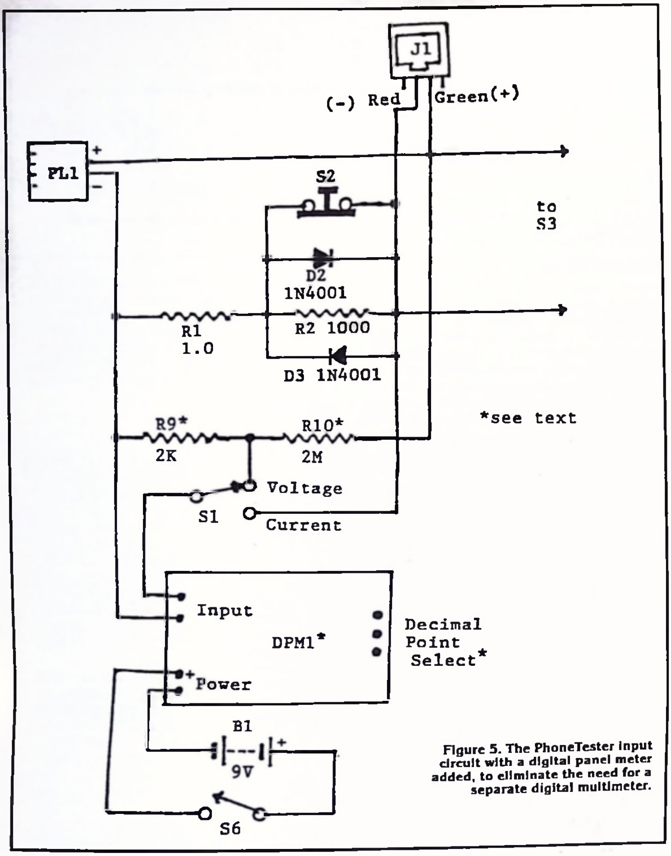


Figure 5. The PhoneTester input circuit with a digital panel meter added, to eliminate the need for a separate digital multimeter.

Parts Suppliers

RadioShack.com
P.O. Box 1981
Fort Worth, TX 76101-1981
1-800-THESHACK
www.radioshack.com

Mouser Electronics
958 N. Main St.
Mansfield, TX 76063-4827
1-800-346-6873
www.mouser.com

MCM Electronics
650 Congress Park Dr.
Centerville, OH 45459-4072
1-800-543-4330
www.mcmelectronics.com

In addition to other parts, the following also carry DPM1:

Jameco Electronics
1355 Shoreway Rd.
Belmont, CA 94002-4100
1-800-831-4242
www.jameco.com

All Electronics
P.O. Box 567
Van Nuys, CA 91408-0567
1-800-826-5432
www.allelectronics.com

Circuit Specialists, Inc.
220 S. Country Club Dr.
Mesa, AZ 85210
1-800-528-1417
www.web-tronics.com

Hosfelt Electronics
2700 Sunset Blvd.
Steubenville, OH 43952-1158
1-888-264-6464

Marlin P. Jones & Assoc., Inc.
P.O. Box 12685
Lake Park, FL 33403-0685
1-800-652-6733
www.mpja.com

microamps of not-in-use current. (The not-in-use current of the RadioShack 43-443 is four to five microamps.) If used, these will raise the total leakage current.

The PhoneTester can also be used at individual telephone jacks to test for proper voltage and polarity, and to test the equipment connected to that jack for leakage and for proper in-use current. As mentioned earlier, FCC regulations specify a maximum current — when the line is not in use — of 10 microamps for each telephone or other unit, and the actual current of most units is much lower.

Optional Circuits

Adding the circuit in Figure 3a to the PhoneTester allows feeding audio from the phone line to a recorder or amplifier. Transformer T1 is a 600 to 600 ohm unit which can be salvaged from an old modem or purchased from most parts suppliers. C2 must have a working voltage rating of at least 100 VAC or 250 VDC, because of the ring voltage. It cannot be a non-polarized electrolytic, they have too much leakage. J4 can be any desired connector; I used a quarter-inch phone jack. This circuit can also be used to feed audio into a phone line (such as for music-on-hold), but it requires a source of low-impedance line-level audio. I have used the headphone jack of a small stereo. I made an adapter with a stereo phone plug at one end and a mono phone plug, to connect to J4 of the PhoneTester, at the other end. A 47-ohm load resistor is connected from each output terminal of the stereo plug to the common terminal. A 600-ohm or larger isolation resistor is connected from each output terminal of the stereo plug to the center terminal of the mono plug.

The basic PhoneTester in Figure 1 allows measurement of the on-hook voltage and leakage current, but a telephone must be connected to J1 to allow measuring the off-hook current and voltage, which could be low because of a high-resistance connection in the wiring. I added the circuit in Figure 3b, a "standard" load, to the PhoneTester to allow measurement of off-hook values without connecting a telephone. On my phone line, this load produces an off-hook voltage of 9.45 VDC, with a current of 26 mA. This will vary slightly on different lines, because of variations in the on-hook voltage and the line resistance. LED2 and LED3 are standard-current (20 mA) LEDs, which also give a second check of line polarity.

A ring indicator which can be substituted for R3 and NE1 is shown in Figure 4. LED4 and LED5 are — like LED1 — low-current (2 mA) units. Without C3, one of the LEDs would light from the 48 VDC on the line. Like C2, C3 must have a minimum working voltage rating of 100 VAC or 250 VDC.

If the PhoneTester will be used frequently, it will be easier to use if it has a built-in meter instead of using a separate DMM. Figure 5 is a schematic of the input portion of the PhoneTester with a digital panel meter, DPM1, added to make a self-contained unit. (This will require a larger case. S3 and the circuit to the right of S3 are the same as in Figure 1.) DPM1 can be one of the low-priced units (about $10.00) available from several parts suppliers. Those with a power supply rating of 7 to 12 volts are usually designed to be used with a nine-volt battery. The DPM basic voltage range should be 200 millivolts. The voltage divider — R9 and R10 — produces a 200-volt range for measuring phone line voltage. The ratio of R9 to R10 should be 1 to 999, but with a ratio of 1 to 1,000 — as in Figure 5 — the error is only 0.1%.

For an important phone line, the circuit in Figure 5 could be used as a permanently

installed line monitor. S3 and the components to the right of S3 in Figure 1 would probably not be needed, except possibly the ring indicator. The values of R9 and R10 would need to be increased to at least 5K ohms and five megohms, with 10K ohms and 10 megohms better, to keep the line-not-in-use current below the FCC requirements. One-percent resistors are not readily available with values above two megohms, so R10 could be made of 1% resistors in series, or by measuring several 5% resistors and using one in the middle of the range.

The nine-volt battery could be replaced by a small nine-volt power supply. However, even with DPMs called "isolated power supply," there is an internal connection between the power terminals and the common input terminal. Since the common input terminal of the DPM is connected to one side of the phone line, the output of the power supply must be well isolated to prevent unbalancing the phone line. Power supplies with a three-prong grounding plug often have the negative output grounded to the plug ground prong. These could not be used, even a fair-sized capacitor from the power-supply output to ground or to one side of the AC line (sometimes used for EMI reduction) could unbalance the phone line.

Problems

Because of the small space between the contact wires in RJ-11 jacks and plugs, spilling any conductive fluid into them may cause leakage between the red and green wires, which are next to each other. When I had this problem in my phone wiring, the only apparent problem was in ringing. The higher ring voltage caused visible sparking between the contact wires, and ringing was weak. This occurred before I built the PhoneTester, but I think the leakage would have shown up in leakage tests with the PhoneTester at the 50 VDC on-hook voltage on the line.

I also have had leakage in S3 of the PhoneTester and in PL1. The leakage in S3 was apparent in the leakage test in the PhoneTester, but to find the leakage in PL1, I built an auxiliary tester. This is an RJ-11 jack with a 1,500-ohm, two-watt resistor connected to the green terminal. I have a bench power supply with a maximum output voltage of about 48 volts. I connected this to the resistor and to the red terminal of the jack, with a DMM, on its 200-millivolt range, across the resistor, making a leakage tester similar to the leakage test in the PhoneTester. The test jack itself is first checked for leakage, then PL1 of the PhoneTester is connected to the test jack to test for leakage in the PhoneTester.

This test jack can also be used to test a telephone or other item without connecting it to a phone line. Power supplies of other voltages — as low as 15 volts — can be used by changing the value of the resistor. Using a typical off-hook voltage and current of 7 volts and 28 mA, a minor rearrangement of the Ohm's Law formula gives the value of resistor R for any supply voltage V:

$$R = \frac{(V - 7)}{0.028}$$

The specifications of the 1N400x series diodes give a maximum reverse leakage current of 10 microamps. This amount of leakage in D1 would affect leakage measurements, although the prototype PhoneTester shows no leakage reading when S3 is in the reverse position. I tested about 25 1N4004 and 1N4007 diodes, using a 50-volt power supply and leakage test circuit of the PhoneTester. None of them gave any reading on the meter, indicating reverse leakage of less than one microamp. It appears that the actual reverse leakage of most 1N400x series diodes is much less than the specified maximum. If you want to be sure of preventing reverse leakage in D1 from affecting leakage measurements, a DPDT switch with a center off position (such as RadioShack 275-664) can be used for S3.

I have mentioned the FCC leakage requirements, but not that the FCC test specifies a test voltage of 100 VDC. Usually, using the PhoneTester with the 50 volts on the phone line or from a power supply will find any leakage, but if you want to test at 100 volts, a suitable power supply can be connected to the auxiliary test jack, with the resistor changed to 3,300 ohms, 5 watts. At 100 volts, the current will be 20 microamps for 5 megohms and 10 microamps for 10 megohms; but be careful, 100 volts can be dangerous, even deadly! **NV**

by Robert Nansel

Amateur Robotics

Next I have a few words to say about the hearts of robot builders. We don't often think about the most important component of our robotics designs — our own personalities. Personality unavoidably affects everything we do, from tools we use to the metaphors by which we describe ourselves, and maybe there's something to learn there. But first, I'll jump right into the PDM.

Power to the Steppers

My four-phase step motors are rated for 1.8A per phase at one volt, and since I'd be driving them with the windings arranged in two sets of two series-connected windings, that meant each motor would require 1.8A at 2V to produce its full rated torque. Since I had three motors to run, I needed a power supply rated for 3 x 1.8 = 5.4A, right? Well, maybe not.

I was puzzled about why Dan Mauch's documentation for the Camtronics three-axis 2A Chopper called for a 10A, 12V supply. By my previous analysis, I "knew" that three 2A step motors would require just 6A. Why had Dan apparently over-designed his power supply? Dan is conservative, but 167% seemed overkill, even for him.

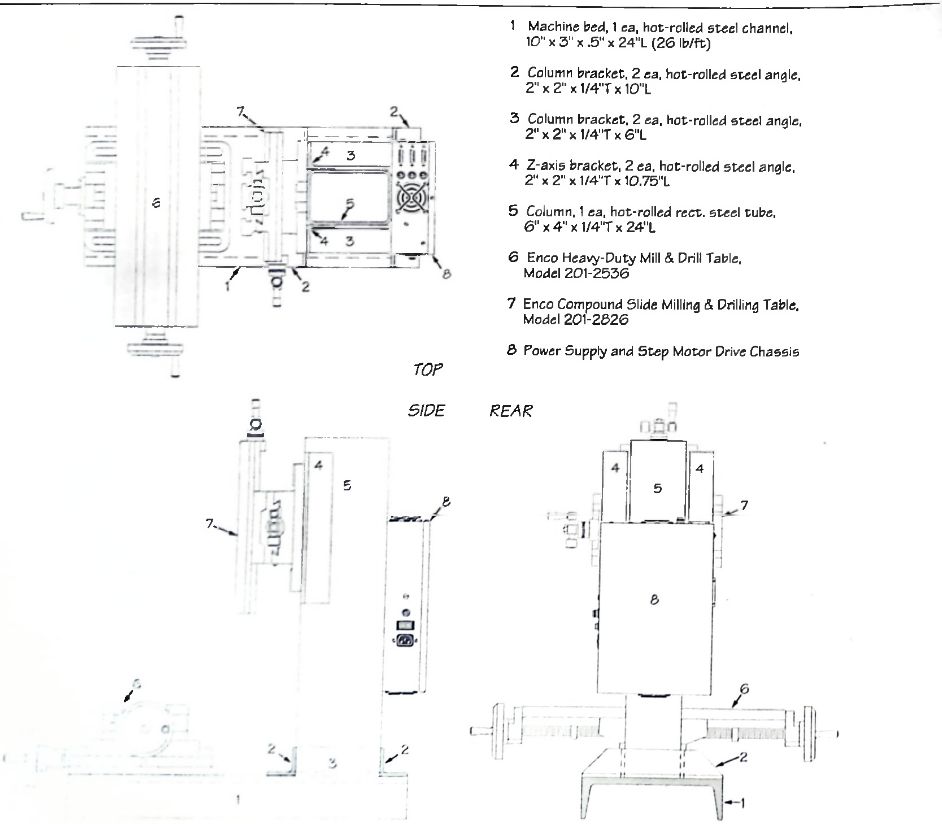
I dug deeper.

The problem, I soon concluded, was with my original analysis. Back when I was designing my power supply, I had neglected to remember that two phases of each motor would be drawing current at a time instead of just one. Call it sleep deprivation or battle fatigue — Nadav was just a month old at the time, so I had some excuse. Whatever the case, I discovered the error long after I had ordered all the parts for a supply designed to produce only 8A. A stupid mistake, I know, but it happens. As a calculus professor of mine once told me, "You know engineers aren't perfect, because otherwise there wouldn't be such things in the world as shims."

Shucks and other saltier comments.

Okay, start over. Three motors with two phases on, means, um, (let's see ... carry the one, drop the calculator, scratch my head, try again ...) I need 3 x 3.6A = 10.8 amps. Throw in a couple 12V cooling fans and the current draw of the chopper drive board, and the current required of the power supply comes to over 11 amps.

That can't be right, can it? The Camtronics board is rated to drive 2A per phase motors. Three such motors would require 12A by this reasoning. Now I was beginning to wonder if Dan had *under* designed the supply. Knowing Dan, this seemed unlikely. What was really going on?



Power Supply Basics

The recommended supply is unregulated, so the voltage presented to the load will vary depending on the load current. With no load, the output of the full-wave rectified DC power supply rises to about 1.4 x the RMS AC voltage of the transformer secondary, less the two diode drops of the bridge rectifier; the output of a 12V supply would be about 12V x 1.4 - 1.2V = 15.6V with no load. Under full-rated load, the voltage pulls down to about 12V.

An unregulated supply always has some ripple in the output voltage (120Hz, if it's a full-wave rectified supply). The amount of 120Hz voltage ripple expected is roughly:

Vripple = Iload / (120 x C)

Dan's design called for a 10,000 MFD cap. At the rated 10A with the same filter cap, the ripple would be about 8V. If the voltage at the ripple peaks was 15V, then the voltage at the troughs would be 15V - 8V = 7V; an important number because the 5V regulator on-board the chopper board requires a minimum voltage input of 7V for proper regulation.

If you draw more than 10A from the supply, the voltage will naturally drop, so at a 12A draw, Dan's supply seemingly shouldn't work at all, at least from the point of view of the 5V regulator. Then, too, if you draw too much current, the transformer would burn up. Was 12A too much?

Was Dan just running the supply at 120% of rated power? Had I somehow gotten the ripple calculation wrong? Step motors and transformers are sometimes able to run at up to 135% rated power without harm.

Time to call Dan.

The Thumb Rules

It turns out I had inadvertently been right the first time I calculated my power supply requirements. Dan explained it to me, but I still don't understand it well enough to explain it to y'all. (I'll get back to you when I do understand it, though.)

I've seen several functioning CNC systems built by Dan, and those systems all worked fine with the 10A power supply. His rule of thumb, based on years of experience driving stepper motors with bipolar chopper drives:

Design as if only one phase per motor will draw current and multiply their combined current draw by a safety factor of 1.25.

The minimum current, then, for a system of three 2A per phase motors is 3 x 2 x 1.25 = 7.5A. For my motors, the minimum would be 3 x 1.8 x 1.25 = 6.75A, so my 8A supply will also work fine (for that matter, my supply would work with 2A motors, too; Dan picked 10A transformers for his supplies because he got a good deal on them).

Yes, the worst case current draw — all three motors stalled and both phases of each energized — is still 12A, and that would be hard on the power supply and the motors. His chopper board takes care of that, though, with an automatic Hold Current feature that drops the current down to a safe level (typically 25% of the running current) when the motors aren't stepping.

Other Design Issues

Once I have basic-level functionality, safety is my biggest concern. In a shop environment with flying dust and metal chips, there are a few must-haves for any electrical equipment:

- Fuses or circuit breakers
- Electrically grounded enclosure
- Visible status

That last point may not be as obvious as the other two. Heavy Iron is an automatic machine tool with potentially dangerous moving parts; just because it's motionless now doesn't mean it can't bite you. It's important to know at a glance what parts of the system are powered up and active. At minimum, you need a lighted power switch and separate power-on indicators for each axis.

Reliability is also a safety concern. Flaky systems are not just annoying, they are dangerous. I attacked reliability by keeping things as simple as practical, both electrically and mechanically.

I always try to visualize what my designs will look like after they've been in service for a long time, covered in grime, scratched up, perhaps dented. Is it still a system I'd like to work with? Will I be able to reach everything easily, and will my tools fit in the space allotted? The shop environment demands a rugged enclosure, but I also want easy access to the internals without the need to tear everything apart.

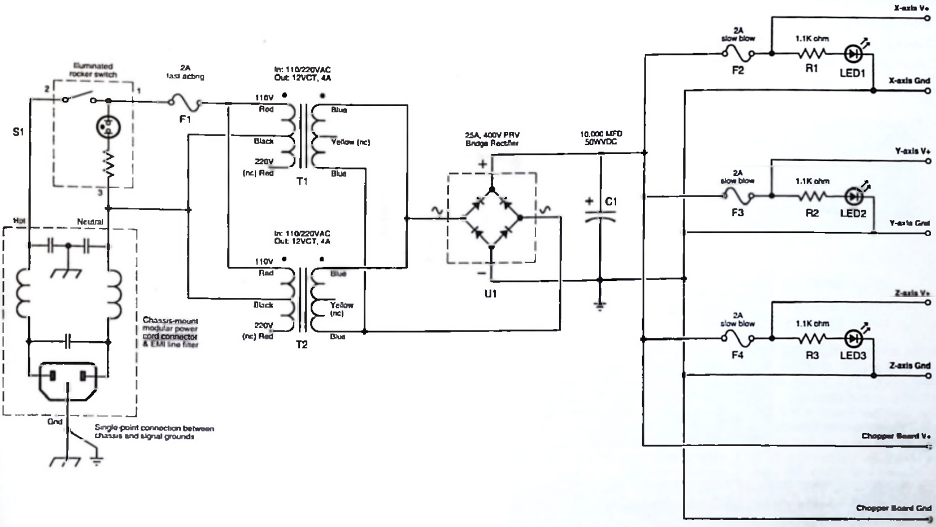
Conflicting Requirements

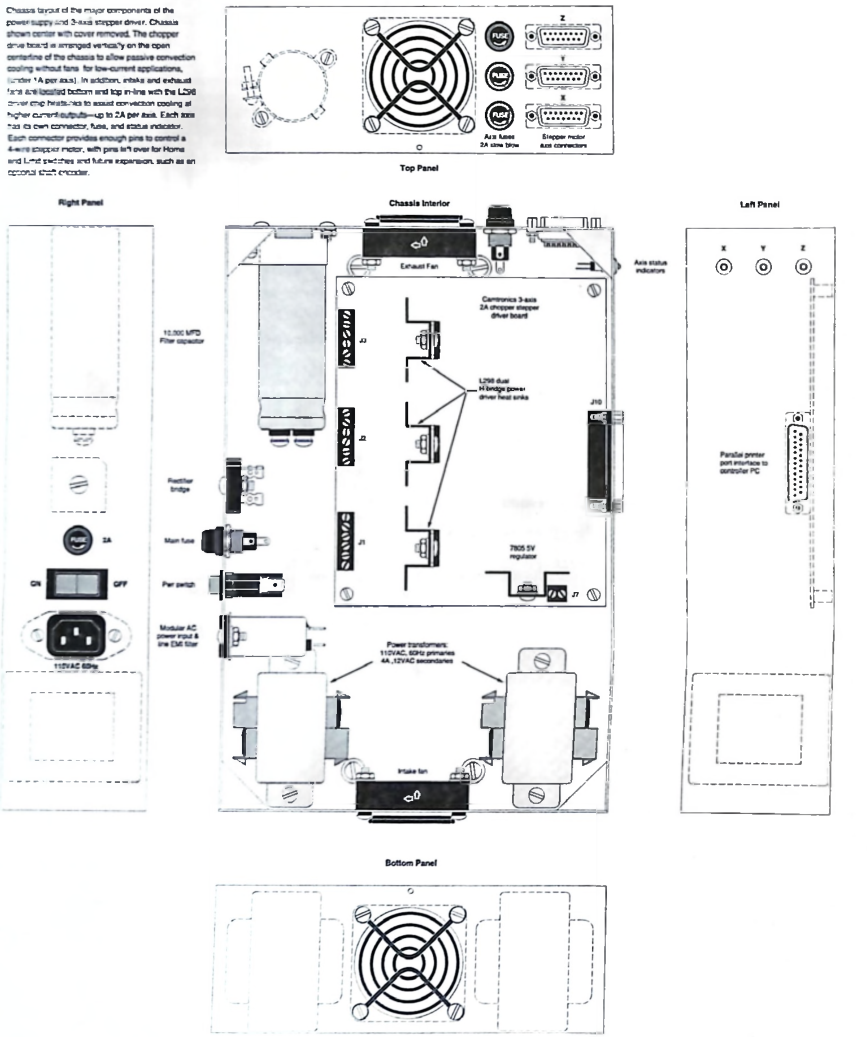
The enclosure must keep out dust and metal chips but allow good ventilation to keep the chopper board cool; it must be big enough to fit the chopper board and power supply, yet small enough to mount on the column of Heavy Iron. It would also be nice if it were cheap, readily available, electrically shielding, and easy to machine with hand tools.

The size and shape of the enclosure are dictated by ease of servicing, the size of the chopper board, and power supply components. Cooling fans are essential, yet I still want to allow for passive convection to supplement the fans; that means allowing for a vertical ventilation path.

My first tradeoff was to use a lower current supply than what Dan's documentation called for. To keep costs low, I wanted to use an off-the-shelf enclosure and parts. Picking the transformer and enclosure was my first order of business.

Dan's 10A transformer, though cheap, was too tall at 3.375" to fit most of the inexpensive aluminum enclosures





Chassis layout of the major components of the power supply and 3-axis stepper driver. Chassis shown center with cover removed. The chopper drive board is arranged vertically on the open centerline of the chassis to allow passive convection cooling without fans for low-current applications, (under 1A per axis). In addition, intake and exhaust fans are located bottom and top in-line with the L298 driver chip heatsinks to assist convection cooling at higher current outputs—up to 2A per axis. Each axis has its own connector, fuse, and status indicator. Each connector provides enough pins to control a 4-wire stepper motor, with pins left over for Home and Limit switches and future expansion, such as an optional shaft encoder.

in which the chopper might also fit. I solved the problem by choosing two small transformers. This turned out to be more flexible — and cheaper.

The Chopper board is 5.6"D x 6.8"W x 2.2"H, and I wanted an inch or two space on all sides of the board. Enclosure choice came down to a 17" x 10" x 4" chassis with plain flat plate cover vs. a chassis 12" x 8" x 3" with cap cover. I chose the latter because it was more rigid with triangular reinforcement gussets; the cover was more rigid, too, and sealed against the environment better. As with the transformers, two small fans were easier to work with than one big one. This allowed me to keep the ventilation axis on the centerline of the enclosure and that, in turn, allowed the main column of Heavy Iron to provide a baffle against flying metal chips entering ventilation openings.

Connections

I chose DB15 connectors to connect the steppers because they are cheap, rugged, dust resistant, and offer enough pins to add extra functionality to individual axes. I investigated military-style circular connectors, but they come with a military-style price: over $16.00 per connector set, compared to under $6.00 for a DB15 set. Plus, they are smaller.

An IEC modular power connector and line filter helps isolate 110 wiring and line noise from the chopper board. Miniature fuse holders save space inside the chassis, with separate fuses for each axis and LED indicators to show status as mentioned earlier. An illuminated switch completes the design.

Alchemy and Bonsai

Whew! All that hard work has put me in a beer mood, and as night follows day, beer leads directly to philosophy. An ongoing interest of mine is the sociology of robot building. I know some folks claim us gearheads have no lives

and that's why we build robots, but I disagree.

In my other life, I'm a science fiction writer, which makes me something of an armchair anthropologist, too. I spend time wondering about what makes people tick. It begins by asking simple questions. My favorite questions have lately been Who builds robots? and Why do they build them? I tend to think of two personality types, which I label the Alchemist and The Bonsai Gardener.

The first is the image of the robot builder laboring alone, secretive, like an Alchemist in a dusty laboratory, programming obsolete microcontrollers, filing aluminum angle, breathing soldering smoke, all energies focused on extracting that one secret that will make robots practical. Believing no one else shares their compulsion to transmute base metals and semiconductors into cybergold, alchemists must invent (and reinvent) the mechanisms and circuitry of their robots — alone.

Robotnugen?

Sometimes, when a robot is only partly done, they sense possibilities of fame and wealth. Like a current, it tugs at them, urging them on. It could happen, you know: a small flash of insight cascading through improbable luck and hard work, seeking to run over finally to that deep pool, the reservoir of hard-won electromechanical truths that make machines work. Call it design elegance, or call it Robotnugen (remember the Volkswagen commercials?), but let this robot be the one that has enough of it to fulfill the dream ...

Mostly the robot never gets finished. In some cases, that's just as well because the act of constructing a failed robot teaches its own valuable lessons; in molding the machine, the builder is molded. It is the best education possible if you are receptive to it. Being open can turn failure into serendipity — the good luck that comes to those who are prepared for it.

Unfortunately, alchemists cling to their preconceptions of how the process should go and, in doing so, create an adversarial relationship with their robots. They strive to force the machine to match the image of the ideal robot. Images are illusion, so their efforts will fail and they will not learn from that failure. Alchemists are not prepared to fail, nor are they really prepared for luck.

Robotic Gardens

How can you prepare for luck? One way is to regularly divest yourself of preconceived notions about what a robot should be. This is the robot builder as a technological Bonsai Gardener, sowing ideas and encouraging growth. Bonsai gardening is as much a discipline as a style. Bonsai gardeners don't seek to wrest secrets from an unwilling universe; rather they persuade potential to emerge. Their relationship to work is that of collaboration between creator and created. Design is a two-way communication process.

Gardeners advance hypotheses, the designs accept or refute, the gardeners reformulate, the robots react, and so on. Like bonsai gardening, building a robot is a process of numerous course corrections, each step small, purposeful. The Bonsai Gardener will change as much as the tree in the end, bending a twig to suit the gardener's will and, in turn, the gardener's will bending to suit the twig. For the bonsai gardener, robotnugen is about the journey, not the destination.

Another aspect of the robot-builder-as-gardeners is they share information with other gardeners. Alchemists rarely share secrets because they must work so hard to mine them in the first place. Gardeners know that ideas are meant to be shared, that they have more than one relationship to the world. If their ideas shape other gardeners' gardens, so will those gardens shape them. Gardeners work for long-term gains; alchemists work for the big splash.

Notebooks

The differences in philosophical outlook between alchemic and bonsai approaches manifest in less mystical/poetic ways, too. Gardeners keep notebooks, not polished, but complete — including failures. And they share their notes with others often.

Alchemists rarely keep adequate notes, and when they do, they tend toward the purpose of proving priority in patent disputes. Their notes obscure and deny failure. They won't share their notes for fear of losing advantage.

Another practical difference is the scale of their projects. Alchemists prefer big, risky projects that reek of individual glory; instead of a lowly office-mail-delivery robot, they prefer battlefield robot tanks, idiosyncratic and incompatible with all that has gone before.

Gardeners work incrementally, building whole systems of carefully crafted modules. Upgrading mail-delivery robots to deliver meals in hospitals is more to their liking than robot tanks. Compatibility and teamwork are their hallmarks.

As with any classification scheme that compartmentalizes people, this alchemist/bonsai dichotomy is a gross oversimplification. We all have both alchemist and bonsai gardener tendencies in us. Both can serve useful functions.

To be a successful robot builder, you must find the proper balance between the lone-wolf alchemist and the bonsai gardener. When you achieve this balance, you will know the bliss of Robotnugen.

Too Much Philosophy

Or too much beer. In either case, I'm outta here. **NV**

If you have suggestions, questions, or comments about amateur robotics topics, you can now reach me at:

Robert Nansel
Box 228
Ambridge, PA 15003

Email: bnansel@nauticom.net

Part	Description	Vender	Vender part #
C1	10,000 MFD. 50WVDC electrolytic capacitor	Mouser	539-CGS50V10000
F1	Miniature fuse (5mm x 20mm). 2A, fast-acting	Mouser	5765-35002
F2-F4	Miniature fuse (5mm x 20mm), 2A, slow-blow	Mouser	5765-39002
Fan1,2	2-3/8" sq. x 9/16" 12VDC box fan	MPJA	12716-FN
J14-J16	DB15 15-pin female connector, solder cup, tin	Digi-Key	1115F-ND
J17-J19	DB15 15-pin male connector, solder cup, tin	Digi-Key	1115M-ND
J20	2-pin right-angle friction lock male header	Digi-Key	WM4300-ND
J21	2-pin center crimp terminal housing	Digi-Key	WM2000-ND
LED1,3	Red, diffused T-1 (3mm), panel-mount LED	Mouser	35CA001
R1-R3	1.1K-ohm, 1/4W, 5% carbon film resistor	Digi-Key	1.1KQBK-ND
S1	Illuminated rocker switch, SPST 15A, 125VAC w. amber neon lamp & internal resistor	Mouser	10DS322
T1, T2	Transformer, 110/220VAC input, 12VAC output	MPJA	7840-TR
U1	25A, 400V PRV bridge rectifier	Mouser	625-GBPC2504
Misc:			
1 ea.	3-axis 2A Chopper/Step Motor Driver kit	Camtronics	
1 ea.	Vertical capacitor mounting hardware	Mouser	539-VR3
4 ea.	Panel-mount miniature fuse holder	Mouser	441-R3-12
2 ea.	Fan guard for 2-3/8" fan	MPJA	8660-FN
1 ea.	6-ft 3-wire IEC cord set	Mouser	173-63101
1 ea.	IEC connector/line filter, 6A 250VAC 50-60Hz	Mouser	562-857-06/27
1 ea.	8"W x 12"D x 3"H aluminum enclosure	Mouser	537-8123
1 ea.	8" x 12" aluminum enclosure cover	Mouser	537-8123C
3 ea.	DB-15 conn. backshell, shielded plastic	Digi-Key	915CA-ND
6 ea.	4-40 female hex screwlock conn. hardware	Digi-Key	160-10F-ND
4 ea.	Hex threaded standoff, alum. 6/32, .25" x .375"	Digi-Key	2209K-ND
2 ea.	Crimp terminals for J10	Digi-Key	WM2200-ND

Suppliers:

Camtronics Inc.
18230 130th Place NE
Bothell, WA 98011-3118
www.seanet.com/~dmauch
email: dmauch@seanet.com

Digi-Key Corporation
701 Brooks Ave. South
Thief River Falls, MN 56701-0677
www.digikey.com
Tel: 800-344-4539, 218-681-6674
Fax: 218-681-3380

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P.O. Box 12685
Lake Park, FL 33403-0685
www.mpja.com
Tel: 800-652-6733, 561-848-8236
Fax: 800-432-9937, 561-848-8299

Mouser Electronics
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Mansfield, TX 76063
www.mouser.com
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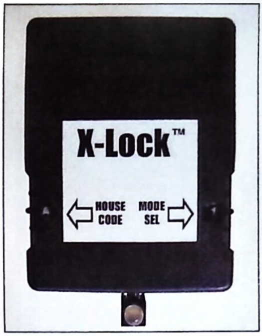
Build the X-Lock



by Jeff Mazur

Build this security module for your X-10 home automation system and never worry again about someone inadvertently controlling your lights and appliances. Best of all, no modifications are necessary to any X-10 modules or the power line — simply plug in the X-Lock and you're protected!

This magazine has given its fair share of coverage to the X-10 brand of products (see Dec. 2000 and May, Jun. 2001 issues). While X-10 has become associated with new security and wireless devices — such as its wireless cameras — it is still best known for the carrier current devices sold under various brand names for the last 20+ years. These lamp and appliance modules have formed the basis for many home control and automation systems. It is this reference to X-10 for which this article applies.

The Problem

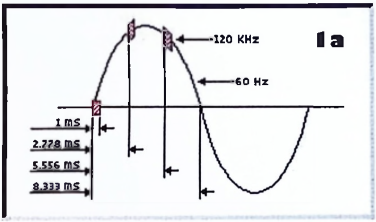
The X-10 system enjoys widespread use for controlling lights and appliances via signals carried over the AC power line. One of the drawbacks of this system, however, is that other homes on the same power feed (or other apartments and offices within the same building) have the potential for interference. Although the system was designed with "house codes" to address this problem, there are several reasons why this is not adequate. To begin with, the interference may not be evident until it's too late. "So what," you might ask, "if someone else controls my appliances?"

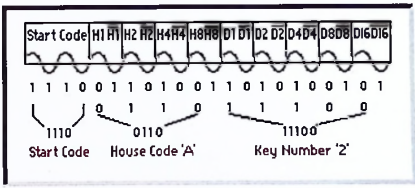
Consider the following scenarios. You control your coffeepot via the X-10 system. One day, a neighbor purchases an X-10 system and starts using it to control his/her home using the same house code (after all, there's only 16 to choose from; I wonder what percentage leave on code A). Or worse yet, the bored teenager next door starts going through all the house codes to see what he (no way it would be "she") can turn on. Either way, your coffeepot turns on — and stays on — for who knows how long (hopefully, you're not out of town). And hopefully you have a home to come home to!

One solution to this problem has been to install a costly and cumbersome power line filter directly to the main circuit panel (assuming you can actually do this). Most likely, the services of an electrician will be required. In apartment and office buildings, this may not even be allowed.

Or picture this. The same coffee pot. You have a friend come over and they bring their toddler with them. While you're talking, you don't notice the child pick up one of your X-10 remotes. Perhaps thinking it's a TV remote — or randomly punching buttons just as children do with the telephone — before you know it that darn coffee pot gets turned on again. Just as you're leaving for the airport!

Figure 1. Details of the X-10 transmission scheme; a) 120 KHz bursts imposed on power cycle, and b) message format for a typical command.





The X-Lock's Interesting Heritage

The initial incarnation of this project involved a rather bizarre combination of components. An old RadioShack Plug 'n Power controller designed for the TRS-80 was commandeered to serve as a temporary interface to the power line. Since designing a circuit to connect directly across the AC powerline can be quite tricky (not to mention dangerous!), this gave me a quick way to begin testing the software. A small modification was necessary to allow the controller to receive, as well as send X-10 commands.

The RadioShack controller was designed to connect with a TRS-80 computer via its cassette in/out interface (yes Virginia, we used to load and store programs on plain old audio cassette recorders). With the help of a simple adapter, I was able to connect this to the brains of this project — an Apple II computer!

Once the concept had been proven, the next step was to design a self-contained, direct AC-powered interface (to replace the RadioShack controller) and to select a microcontroller to replace the Apple II.

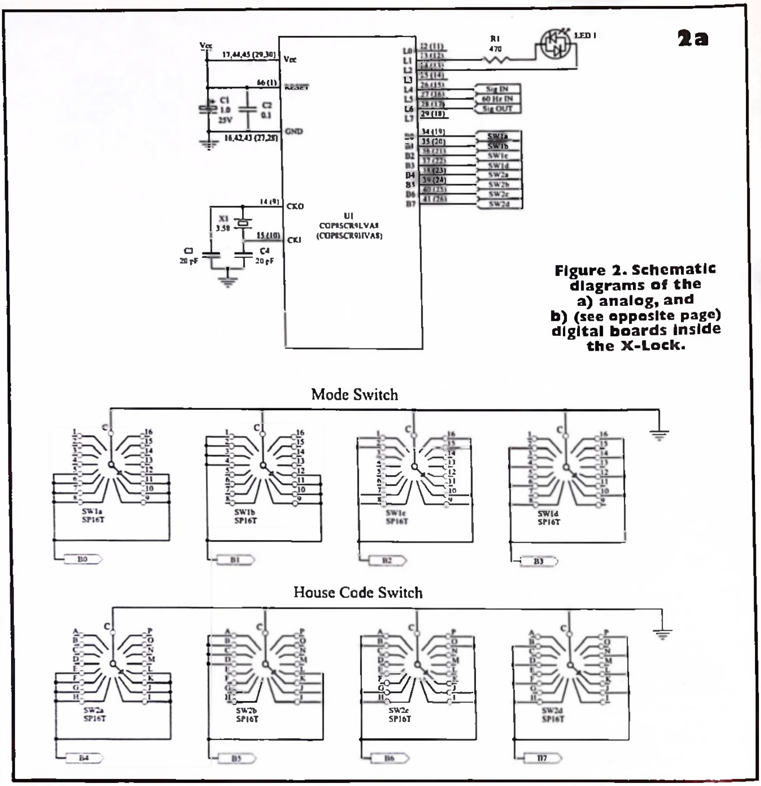


Figure 2. Schematic diagrams of the a) analog, and b) (see opposite page) digital boards inside the X-Lock.

The Solution

While these scenarios might seem a bit melodramatic, the truth is any unwanted control of your devices would at best be an annoyance. And the addition of a simple "security module" can add much peace of mind to your entire home control system. The module described here is just such a device. It simply plugs into the wall anywhere in your house, and provides protection against unwanted commands controlling your lamps and appliances. No wiring changes are necessary. Just dial in your house code and plug it in!

Once installed, you go through a brief training mode where you set up passcodes (from 1 to 7 digits) to arm and disarm the security feature. Then you can place the module into one of two security modes. For casual use and highest security, use the single deactivation mode. With this function enabled, no modules can be controlled without first entering the disarm passcode as a prefix. Once entered, the system will allow commands to be sent for only a short preset amount of time (or until no commands have been entered for that amount of time). Any commands issued outside this window will be ignored preventing the neighbor or toddler from accidentally doing harm.

The other mode operates more like an alarm security system. Here you use your arm and disarm passcodes to enable and disable the X-Lock module appropriately. Thus, you might arm the module when you leave for the day and disarm it when you return. This obviates the inconvenience of having to enter a code each time you wish to control something.

So now, instead of unplugging all of your modules before you leave on a trip, a simple ALL UNITS OFF command followed by your arming passcode will let you rest assured that you didn't leave anything on. And if you use computer or timer controls to automate your house, they can easily be programmed to issue the passcodes giving you both automatic and secure control of your devices.

How it Works

The details of X-10 signaling have been covered in many previous articles, so we'll just review the basics needed to explain the operation of the X-Lock. Figure 1 shows the format of a typical X-10 transmission. Note that every data bit is sent twice — once in true form and then immediately followed by its inverse — or negated — value. Every message (except bright/dim commands) is also sent two times in its entirety.

Signaling is accomplished by imposing three 1 mS bursts of 120 KHz RF onto the line during a half cycle of the power frequency (60 Hz in the US) to indicate a "one;" the absence of these bursts indicates a "zero." Note that the bursts are synchronized to the 60-Hz line frequency and timed to begin just after a zero crossing. A special "start code" precedes every command stream to signal that a new transmission is beginning.

For more info on the X-10 specifications and protocol, see one of the various websites cited in the reference section.

To prevent unwanted X-10 signals from activating our modules, we need to constantly listen on the power line for any activity. As soon as a start code is received, we can presume that a valid X-10 command is being sent. The next four bits received indicate the house code associated with the command. At this point, we can determine if this house code is "ours." If so, we need to examine the transmission further; otherwise we can ignore the rest of the signal since it is for someone else's module.

If the command house code matches ours, we then need to determine whether the command represents a number button (1-16) or an "action" command. This depends upon the last data bit (D16); a one in this "function" bit signals that this is an action such as ON, OFF, or DIM. This is where the X-Lock springs into action.

If it senses a real action command being sent to our house code — and assuming the X-lock has not been previously disarmed — it somehow needs to block the command from being recognized by the module being addressed. It does this by sending a high level "jamming" signal that is simply just 70 mS of the 120-KHz carrier. This jamming signal overrides the remainder of the rogue command and the beginning of the second, repeated command. This prevents the lamp/appliance module from recognizing a valid command and it will not

2b

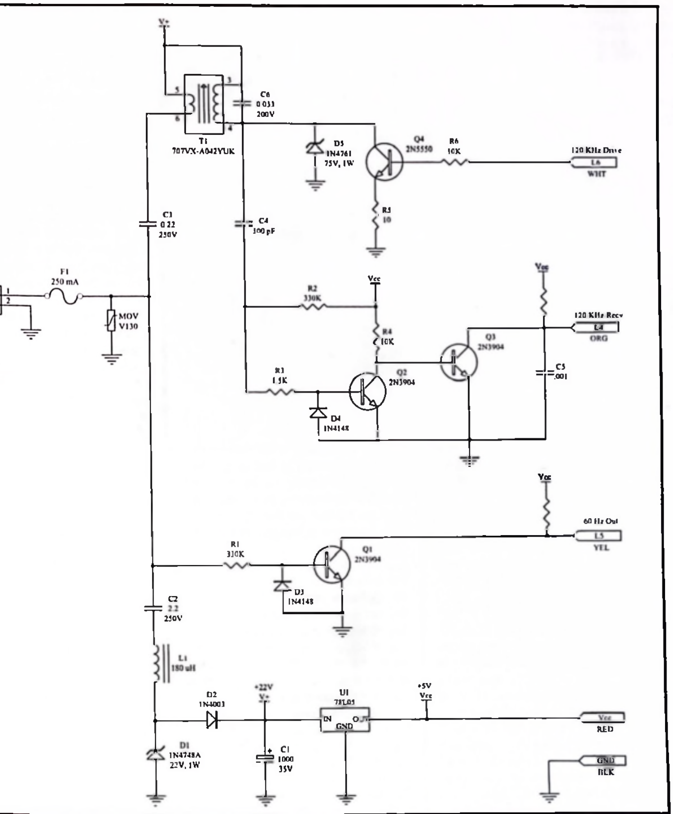
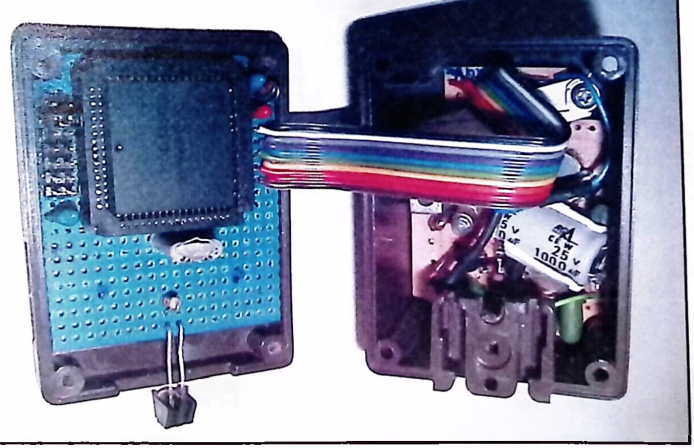


Figure 3. Digital board on left connects via ribbon cable to analog board on right.



respond. Actually, most modules require both transmissions to be error free before they react; but just to be sure, we jam in the middle of the function bit of the first transmission to make sure no valid streams get through.

When not jamming, the X-Lock also looks for the proper arm and disarm passcode sequences. In Mode 1 (high security, single deactivation operation), when the disarm passcode is correctly received, the X-Lock temporarily goes to sleep allowing the following authorized commands to be sent unjammed. While snoozing, it keeps an ear on the line and waits until no more signals have been transmitted for a preset amount of time.

When this window closes, the X-Lock re-arms itself and begins protecting the line again. In Mode 2 (arm/disarm operation), the disarm passcode permanently disables the X-Lock until the arming code is received.

One minor detail is also accomplished whenever disarming the X-Lock. Since the passcode numeric keys are received by all modules while they are entered, any action keys pressed after entering the passcode would be acted upon by these modules.

In other words, if the passcode was 1-2-3 and then you pressed 4 ON to turn on module 4, modules 1, 2, and 3 would also go on. To prevent this, the X-Lock sends a dummy command (actually the seldom used HAIL ACK command) just before disarming. This resets any previously addressed modules so they do not respond.

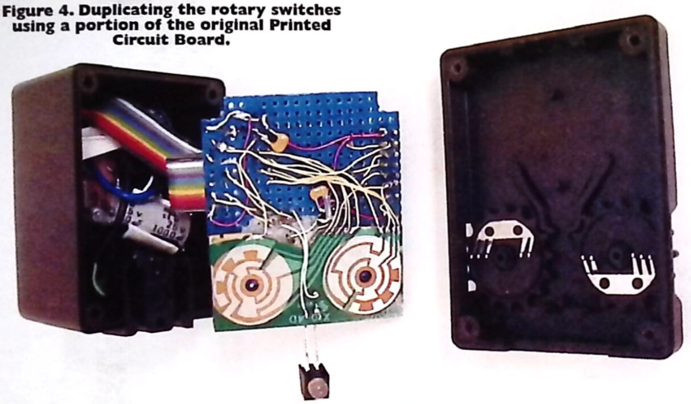
Microcontroller Selection

As for the brains of this device, several microcontrollers were examined. Readers of this magazine may be very familiar with the PIC controllers from MicroChip. Many X-10 designs have been built around these chips. They are inexpensive and easy to program. For this design however, I chose to use a COP8FLASH microcontroller from National Semiconductor.

The COP8FLASH microcontroller family provides a number of features, which make the design of this device much simpler. In several cases, specific features of the microcontroller allowed a function normally designed in hardware to be moved into the software code, adding flexibility and reducing parts count (and, of course, cost).

For example, the design calls for a keyable, 120 KHz oscillator. In almost every other X-10 implementation, this is provided by an analog circuit using tuned components. While having a CPU generate this signal sounds trivial, very few microcontrollers would be up to the task. Creating this signal using a software loop would require very fast instruction times, not to mention the difficulty in creating a symmetrical loop and maintaining a stable frequency and duty cycle for an extended period.

Figure 4. Duplicating the rotary switches using a portion of the original Printed Circuit Board.



Initially, I planned to rely upon an external oscillator using the microcontroller to simply gate it on and off. However, the PWM mode of the COP8 timers seemed perfect for the job. Using the high-speed mode, I was easily able to create an independent oscillator and control the phase of its off state. I even found a way to calibrate the frequency, further eliminating parts from the hardware side. All in all, quite a savings in parts, board space, and manual construction.

Non-volatile storage was essential to saving user parameters across power outages. Since only a small amount was needed, the ability to create a Virtual EEPROM within the on-chip flash memory made for a very efficient design. Elimination of other components — such as two rotary switches — is also possible with software, although this would complicate the user interface and operation appreciably.

High current drive allowed a bipolar LED to connect directly across two data outputs for user feedback.

Another part-saving design is the 120 Hz interrupt generator. Normally, this requires a full wave bridge supply or a differentiator to create 120 Hz from the 60-Hz power line. The bridge approach adds complexity and prevents using one leg of the power line as a common ground. A differentiator would add an asymmetrical delay to the zero crossing detection.

Instead, this design uses the programmable edge detection on the interrupt inputs available in the COP8. Thus, after triggering on the positive edge of the power cycle, the COP8 is reprogrammed to look for the next negative edge. The next interrupt then reverses this and the cycle repeats.

Low power CMOS technology may not seem vital to this design, however being powered directly off the AC powerline places several restrictions on the size of components for a given supply current. Thus, the COP8's low power requirements translated into an efficient, low-cost power supply circuit. Other power-saving features of the COP8 may prove useful in future designs that add battery back-up operation.

Building the X-Lock

After building a prototype to test out the feasibility of this design (see sidebar, "The X-Lock's Interesting Heritage"), I examined the options for building a self-contained interface. Anyone who has tinkered with X-10 and computer control is probably aware of the TW523 interface which X-10 makes available for such projects. However, the TW523 does not output the data stream during the first transmission and unfortunately, this design "feature" makes it unsuitable for our purposes.

Therefore, all of the functions of receiving and transmitting X-10 signals would have to be included, as well as a control system. To be truly self-contained, a power supply would also have to be built within the module. The complete schematic is shown in Figure 2.

The simplest way to construct this project is to "cannibalize" a lamp or appliance module; if you have a defunct module, all the better. Several key components can be salvaged from the module (unless, of course they were the reason the module failed) and the empty case is a perfect enclosure for the completed project.

Like the donor module, the X-Lock is built on two circuit boards: a digital board and an analog board (see Figure 3). The digital board contains a single active device — the COP8FLASH microcontroller (MCU). Except for a few bypass capacitors and programming header, the only other circuitry on this board is a 3.58-MHz crystal with its load capacitors and a dual color LED.

On the back of the digital board, circuit traces implement the two 16-position rotary switches. This is easily accomplished using a cut-off portion from the donor module to provide this function (see Figure 4). This board mounts to the top half of the module case, where the wiper portions of the rotary switches reside. The digital board then connects to the analog board inside the bottom half using a five-conductor ribbon cable.

The analog board comprises a power supply and interface circuitry to condition the 60-Hz and 120-KHz detectors and the 120-KHz drive signal. The power supply has rather unusual requirements in that it must connect directly across the 120-VAC power line, drop a considerably high voltage without dissipating too much power, handle the transients and noise commonly found, and allow coupling of the 120-KHz signals. A power transformer could be used, but would unduly add to the cost and size of this device.

Like other devices designed for power line carrier communications, this module uses a capacitor to isolate and drop most of the incoming 120V (340V P-P) AC signal. A rectifier and zener provide a rough 22V supply. An RF choke is also placed in series with the incoming line to keep the power supply from swamping out the signaling RF imposed on the line. The 22-volt supply is used solely by the 120-KHz drive circuit via a tank coil which is part of a tuned circuit to couple as much signal to the line as possible. This supply also feeds a 78L05 regulator IC that provides +5V to the remaining circuit (including the MCU).

The same tuned transformer used by the drive circuit is also used by the 120-KHz RF detector. The RF present on the line is multiplied by the turns ratio of T1 and the Q of this circuit (roughly 7-10) yielding a .2-50V P-P signal, which is fed to a squared/integrator (Q2, Q3, and C5). The output from the integrator is normally high, but remains low as long as the 120-KHz RF is present.

This signal is presented to the D4 bit of Port L of the MCU. More elaborate detector circuits could be used (such as one based on the obsolete LM1893 Carrier-Current Transceiver), but this simple design has proven very effective.

The power line is also squared and buffered by Q1 to provide a reference signal to the MCU. This signal is applied to the D5 bit of Port L. The program detects both positive and negative zero crossings of the power line to synchronize the detection algorithm.

The MCU generates a 120-KHz signal to "talk" on the power line. This squarewave is independently created by the MCU Timer 3 operating in its PWM mode. Thus, the program only needs to set a single control bit to toggle the oscillator on or off. This signal, which comes out the T3A pin of the MCU, is used to drive Q4 which places the drive signal across the sec-

PARTS LIST

Analog Board

C1 - 1000 uFd, 35VDC electrolytic capacitor
C2 - 2.2 uFd, 250V NP mylar capacitor
C3 - 0.22 uFd, 250V NP mylar capacitor
C4 - 300 pF, 100V capacitor
C5 - 0.001 uFd capacitor
C6 - 0.033 uFd, 200V polypropylene capacitor
D1 - 1N4748A zener diode, 22V, 1W
D2 - 1N4003 diode, 200V, 1A
D3,D4 - 1N4148 silicon diode
D5 - 1N4761A zener diode, 75V, 1W
F1 - 250 mA fuse
L1 - 180 uH, 250 mA inductor
MOV - V130 type transient suppressor
P1 - line cord/plug
Q1-Q3 - 2N3904 NPN transistor
Q4 - 2N5550 NPN HV transistor
R1,2 - 330K ohm 1/4W carbon resistor
R3 - 1.5K ohm 1/4W carbon resistor
R4,R6 - 10K ohm 1/4W carbon resistor
R5 - 10 ohm 1/4W carbon resistor
T1 - 120 KHz signal transformer (Toko P/N 707VX-A042YUK)
U1 - 78L05 regulator IC, 5V

Digital Board

C1 - 1 uFd, 25VDC tantalum capacitor
C2 - 0.1 uFd, 25VDC mono capacitor
C3, C4 - 20 pF capacitor
LED1 - bipolar, three color LED
R1 - 470 ohm 1/4W carbon resistor
SW1, SW2 - 16 position, 4 pole switch
U1 - COP8SCR9 microcontroller
X1 - 3.58 MHz crystal

ondary of T1. The tuned circuit creates a nice sinewave, which is coupled onto the power line.

The Firmware

Listing 1 (which is available for download at www.nutsvolts.com) shows the software needed to run the X-Lock. It is burned into the CPU's flash memory and controls the entire operation. If anybody adapts this code to work on a PIC, let me know!

Installation and Passcode Programming

Set the House Code switch on the X-Lock to match your other modules. Set the Mode Switch (Unit Code) to position 16 (Passcode Programming). Plug the X-Lock into any convenient outlet. You may wish to choose a location where you can see the module and its indicator LED.

Setting the X-Lock Mode switch to position 16 allows you to program the disarming and (optional) arming passcodes. Each passcode can consist of 1-7 "digits," where a digit is any numeric or function key except DIM. Programming can be accomplished from any controller. Follow this procedure to enter your passcodes:

1. Set Mode switch to position 16. LED should be off.
2. Press the "DIM" key. LED should blink red.
3. Enter up to seven digits for your disarm passcode. Note that some controllers send two commands for a single keypress (e.g., 2-ON). This would be considered two digits and may require two buttons on other controllers.
4. Press the "DIM" key again. LED should blink green.
5. Optionally, enter up to seven digits for your arm passcode (used by some modes).
6. Press the "DIM" key once more. LED should turn off.
7. After programming, change the Mode Switch to the desired operating mode position (see below).

NOTE: You can skip step 5 if you do not want a separate arm code; in this case, the arm code will be the same as the previously entered disarm code.

Operation

Simply dial in the desired operating mode. You may choose from:

Hi-security mode (Mode 1)

In this mode, the X-Lock will continuously monitor the line and prevent any X-10 activity. This is indicated by the red LED showing that the system is armed. To control your devices, you will first need to enter the disarm passcode. After entering the proper code, the X-Lock will disarm (LED turns green). You can now send whatever commands you wish. The system will remain disarmed for a fixed period of time following the last command issued (i.e., until no keys have been pressed for that amount of time). The default time is 12 seconds but may be changed using the Advanced Programming mode. When the disarm period expires, the X-Lock will return to the armed mode and prevent any further access.

Arm/disarm mode (Mode 2)

When the mode switch is placed in position 2, the LED will turn red, indicating that the system is armed. When you wish to gain access, enter the disarming passcode (LED turns green). This allows unrestricted control of your X-10 modules. To restrict access again, enter the arm passcode.

Advanced programming mode (Mode 15)

Used to change the disarm window time.

1. Set Mode switch to position 15. LED should be off.
2. Press the "DIM" key. LED should blink green.
3. Enter desired time key (see table). LED will go off.
4. After programming, change the Mode Switch to the desired operating mode position.

Window Timing Table

Key	Time (sec)
3	8
7	20
14	32
10	60

Other LED Indications

When the system is armed, the LED will flash green when it detects any attempt to send a command.

If the X-Lock detects an error condition, it will disable itself and alternately flash red and green. Move either switch to reset the X-Lock.

Computer Control

If your X-10 system contains any timer or computer interfaces, you will need to re-program them to send the disarm code before each command (or set of commands, if they are sent as a group). Since many controllers must send an "action" key with each program step, you should pick a passcode such as 13-ON, 12-OFF, 13-OFF.

Of course, the same applies to sending the arm code for Mode 2. However, since the system is "active" while the armcode is being sent, these commands will be acted upon by any modules that happen to be addressed. Using the previous code as an example, this would cause module 13 to go on then off and module 12 to go off. For this reason, you may wish to restrain your passcodes to unused unit numbers. **NV**

REFERENCES

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LM1893/LM2893 Carrier Current Transceiver Datasheet, National Semiconductor, 1995.

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Main X-10 commercial site and technology theory

http://www.x10.org/

http://www.smarthomeforum.com/x10.shtml
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http://www.automationfaq.com/fom-serve/cache/4.html
FAQ pages

http://nav.webring.yahoo.com/hub?ring=homeauto&list
http://www.concentric.net/~Reboston/list.html
Home Automation forums

http://www3.edgenet.net/lingling/x10-mods.html
http://www.nysaes.cornell.edu/cc/staff/pool/homeauto/
Schematics of X-10 stuff and other hobbyist info.

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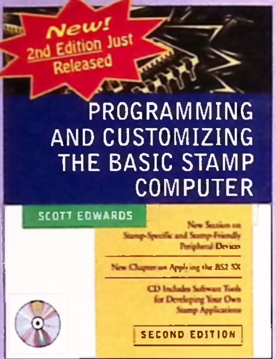

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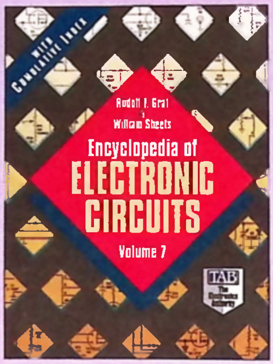

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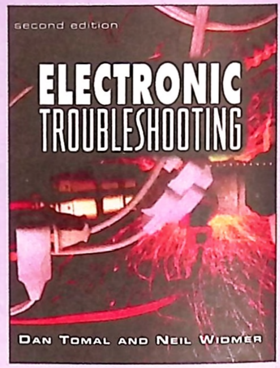

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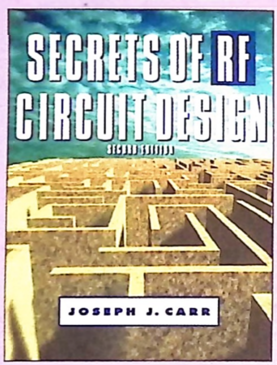

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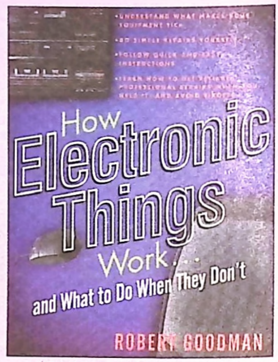

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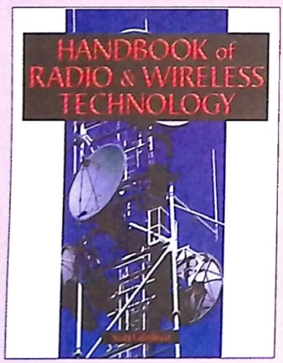

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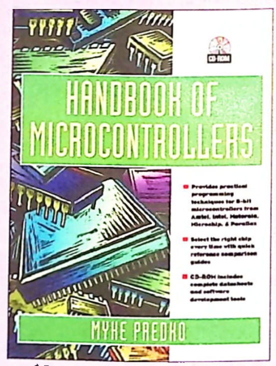

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New Product News

Mini-FlashLED™

LEDtronics announces the Mini-FlashLED™ pocket flashlight, the newest addition to its line of high-powered LED flashlights that integrate a 5mm discrete LED lamp, an anodized aluminum casing, and a cabochon lens that optimizes the light intensity.

LED light output – measured in End Foot Candles (EFC) – is impressive: Blue 32 EFC, Green 140 EFC, White 150 EFC, Red 100 EFC, and Yellow 30 EFC.

This pocket-sized light measures just 5" in length and weighs only 2.1 ounces, making it ideal for carrying in briefcases, backpacks, purses, and toolboxes.

The long-lasting LED lamp operates for more than 100,000 hours (10 years) before requiring replacement. Energy-efficient, Mini-FlashLED operates between 9[illegible] and 257 hours depending on the LED [illegible] on three replaceable E90 N-cell [illegible] batteries or equivalents. Also, th[illegible]-FlashLED can house and run on [illegible]A alkaline batteries further extend[illegible] operating time by reducing bright[illegible]

Mini-FlashLED is available in six colors: Cool White, Ultra Red, Orange, Yellow, Aqua Green, and Pure Blue.

Price is $26.50 per flashlight. Ask for datasheet #105.

For further information, contact:

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TORRANCE, CA 90505
310-534-1505 FAX: 310-534-1424
WEB: www.ledtronics.com

WORKMAN MOBILE ROBOT PLATFORM

The Workman Mobile Robot Platform was created to be the basis of a specialized mobile robot. Suitable for applications such as education, industrial inspection, fire-fighting, etc., Workman provides plenty of surface area for sensors and other devices. Also ideal for the hobbyist, Workman addresses the problem most robot builders face: designing a suitable platform. Measuring 15"L x 19"W x 10"H, Workman solves this problem, enabling you to focus on the design and implementation of the internals such as controller, power source, batteries, etc.

The Workman platform is user-friendly. Made of four individually molded plastic enclosures, it is easily drilled or modified to accommodate your application. The modular design provides compartments for your internals. Two of the compartments house the motors (included), while the two remaining compartments contain components that you specify. For instance, one compartment could contain a controller board, while the other could house battery and radio receiver.

Boasting 8" drive wheels, 6" rear swivel wheels, and two high-torque worm-gear motors, this machine is a dynamo. Available in kit-form or completely assembled, Workman is powerful, able to scale small obstacles with ease. It can handle light-to-moderate jobs such as pulling, pushing, or carrying small loads.

The Workman Mobile Robot Platform kit sells for $239.00 (unassembled). Manual with photos included.

For more information, contact:

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A programming adapter to adapt the 68-pin UV erasable 18C658 to the Microchip PICSTART-PLUS 40-pin DIP connector is also available. This will allow program development for the 18C658 using the Microchip development programmer.

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DRIVER16 EXPANSION BOARD

JK microsystems, Inc., now has the new Driver16 expansion board available for shipment.

This new addition to the product line provides many JK microsystems single board computers the ability to convert regular TTL level I/O lines into as many as 16 high-current outputs.

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Starting at $29.00 for one unit, the Driver16 is aggressively discounted with quantity orders. The development kit, which is only $39.00, contains a Driver16 and all the items necessary for integration with the industry proven LogicFlex, Flashlite 386Ex, or V25 controllers.

For additional information, contact:

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